PHILOSOPHICAL

TRANSACTIONS.

I. *On the effects of temperature on the intensity of magnetic forces; and on the diurnal variation of the terrestrial magnetic intensity.* *By* SAMUEL HUNTER CHRISTIE, *Esq. M. A. of Trinity College, Cambridge, Fellow of the Cambridge Philosophical Society: of the Royal Military Academy.* *Communicated by the President*

Read June 17, 1824.

IN the paper on the diurnal deviations of the horizontal needle when under the influence of magnets, which the President did me the honour to present, I stated that these deviations were partly the effects of changes that took place in the temperature of the magnets; and that although the conclusions which I drew from the observations respecting the increase and decrease of the terrestrial magnetic forces during the day would not be materially affected, it was my intention to undertake a series of experiments for the purpose of determining the precise effects of changes of temperature in the magnets, so as to be able to free the observations entirely from such effects.

These experiments were immediately made; but I was induced from some effects which I observed, to carry them to

a greater extent, in the scale of temperature, than was necessary for the object which I had at first in view. In consequence of this, and the length of the calculations into which I have been obliged to enter, the accomplishment of my purpose was delayed for a considerable time, and continued indisposition has since prevented me, until now, completing the arrangement of the tables of results.

In the present paper, I propose to detail the experiments which I made in order to determine the effect of changes of temperature on the forces of the magnets, to the extent to which I observed their temperature to vary, during my observations on the diurnal changes in the direction of the needle, when under their influence; to apply the results which I obtained to the correction of the observations themselves, thereby accounting for the apparent anomalies noticed by Mr. Barlow and myself, in the observations made in doors and in the open air; and by means of these corrected observations, to point out the diurnal variations in the terrestrial magnetic intensity.

It had been my intention to determine purely from observation the portion of the arc of deviation due to the changes which I noticed in the temperature of the magnets; but I found that this depended so much on the situation of the point at which the needle was held in equilibrio by the terrestrial forces and those of the magnets, that it would hardly be possible to determine how much of this portion was due to the extent of the change of temperature, or the degree of temperature where the change took place, and how much to the azimuth of the needle, when affected by this change. I was therefore under the necessity of having recourse to

theory, and adopted the simplest, and that which is most generally received, viz. that the forces which two magnets exert upon one another may be referred to two centres or poles in each, near their respective ends; and that for either pole in one of the magnets, one pole of the other magnet is urged towards it, and the other from it, by forces varying inversely as the squares of their respective distances from that pole. Of the correctness of this theory of the action of one magnet upon another, the conclusions which I have obtained have given me no reason to doubt.

In the observations on the diurnal changes in the positions of the points of equilibrium at which the pole of the needle was retained by the joint action of two magnets and the terrestrial magnetism, where I noted the changes that took place in the temperature of the magnets, to which observations I have alluded near the conclusion of my former paper, two magnets, as in several of the preceding observations, were placed, with their axes in the magnetic meridian, on the same horizontal table as the compass, at equal distances from the centre of the needle, one towards the north, the other towards the south, the north pole of each magnet being towards the north; and their distances from the centre were such, that the points of equilibrium were nearly 180°, or south, N. 80° E. and N. 80° W. To determine here the changes that would take place in the situation of these points from changes in the force of the magnets, arising from a variation of their temperature, it was first necessary to determine the changes in the forces themselves, arising from certain variations of the temperature of the magnets, by observing the corresponding changes in the direction of the needle.

To obtain the equation requisite for this purpose, take the centre of the needle as the origin of the rectangular co-ordinates, the axis of the x's being in the magnetic meridian. Let x and y be the co-ordinates to the south pole of the needle, x being measured towards the north, and y towards the west: also, let r be the distance of either pole of the needle from its centre; ρ the distance of the poles of each of the magnets from their respective centres; and R the distance between the centre of the needle and the centre of either magnet. For the sake of expressing clearly and concisely the distances between the poles of the needle and those of the magnets, we will indicate these points as follow:

s, the *south* pole of the needle; that is, the pole which, when the needle is freely suspended, points towards the *north*;

n, the *north* pole of the needle;

σ_N, the *south* pole of the magnet which is to the *north* of the needle; that is, its pole *nearest* to the centre of the needle;

ν_N, the *north* pole of the same magnet, or its pole which is *furthest* from the needle's centre;

σ_S, the *south* pole of the *south* magnet, or that pole which is *furthest* from the centre of the needle;

ν_S, the *north* pole of the same magnet, or that pole which is *nearest* to the centre of the needle.

Now resolve the terrestrial magnetic force acting on the north arm of the needle, in the line of the dip, into two; one horizontal or in the direction x, and the other vertical: and let the horizontal force be M. Also, let the force with which a pole of the needle is repelled from the pole of the same name of either magnet, or attracted towards that of a con-

trary name at the unity of distance, be F: then the forces acting on the south pole of the needle will be,

M in the direction x;

$-\frac{F}{(s\sigma_N)^2}$, in the direction $s\sigma_N$; $\frac{F}{(s\nu_N)^2}$, in the direction $s\nu_N$;

$-\frac{F}{(s\sigma_S)^2}$, in the direction $s\sigma_S$; $\frac{F}{(s\nu_S)^2}$, in the direction $s\nu_S$.

The north pole of the needle will be urged by forces equal and parallel to these, but in contrary directions; so that in investigating the conditions of equilibrium of the needle, we may consider only the equilibrium of the south pole urged by forces double of the preceding, and constrained to move in a circle; and it is evident that the equation of equilibrium will be the same, whether we take these forces, or the doubles of them.

Resolving these forces into others in the directions x and y, calling X the sum of all the forces in the direction x, and Y the sum of all the forces in the direction y, we shall have,

$$X = M - F\left\{\frac{R-\rho-x}{(s\sigma_N)^3} - \frac{R+\rho-x}{(s\nu_N)^3} - \frac{R+\rho+x}{(s\sigma_S)^3} + \frac{R-\rho+x}{(s\nu_S)^3}\right\}$$

$$Y = F.\left\{\frac{y}{(s\sigma_N)^3} - \frac{y}{(s\nu_N)^3} + \frac{y}{(s\sigma_S)^3} - \frac{y}{(s\nu_S)^3}\right\}$$

The general equation of equilibrium for a point acted upon by forces in the same plane, and constrained to move in a curve whose equation is $L = o$, is

$$X\,dx + Y\,dy + \lambda\,dL = o. \qquad (1)$$

From this we obtain

$$X + \lambda.\frac{dL}{dx} = o, \text{ and } Y + \lambda\frac{dL}{dy} = o;$$

whence

$$X.\frac{dL}{dy} - Y.\frac{dL}{dx} = o \qquad (2)$$

The equation $L = o$ is in this case,

$$x^2 + y^2 - r^2 = o\,;$$

and consequently $\quad \frac{dL}{dx} = 2\,x, \ \frac{dL}{dy} = 2\,y.$

The equation (2) therefore becomes

$$X y - Y x = o.$$

Substituting in this equation the values previously found for X and Y, and dividing by y, we obtain

$$M - F.\left[(R-\rho)\,.\left\{\frac{1}{(s\sigma_N)^3} + \frac{1}{(s\nu_S)^3}\right\} - (R+\rho)\,.\left\{\frac{1}{(s\nu_N)^3} + \frac{1}{(s\sigma_S)^3}\right\}\right] = o \ldots\ldots\ldots (A)$$

Let φ be the angle which the axis of the needle makes with the meridian, or the azimuth of the point of equilibrium, and we shall have,

$$(s\sigma_N)^2 = (R-\rho)^2 + r^2 - 2\,r(R-\rho)\cos.\varphi\,; \quad (s\nu_S)^2 = (R-\rho)^2 + r^2 + 2\,r(R-\rho)\,.\cos.\varphi\,;$$

$$(s\nu_N)^2 = (R+\rho)^2 + r^2 - 2\,r(R+\rho)\cos.\varphi\,; \quad (s\sigma_S)^2 = (R+\rho)^2 + r^2 + 2\,r(R+\rho)\ \cos.\varphi.$$

Substituting these values in the equation (A), it becomes,

$$M - F.\left\{\begin{array}{l} \dfrac{R-\rho}{\left\{(R-\rho)+r^2\right\}^{\frac{3}{2}}}\,.\left\{\dfrac{1}{\left\{1-\dfrac{2\,r\,(R-\rho)}{(R-\rho)^2+r^2}\,.\cos.\varphi\right\}^{\frac{3}{2}}} + \dfrac{1}{\left\{1+\dfrac{2\,r\,(R-\rho)}{(R-\rho)^2+r^2}\,.\cos.\varphi\right\}^{\frac{3}{2}}}\right\} \\ -\dfrac{R+\rho}{\left\{(R+\rho)^2+r^2\right\}^{\frac{3}{2}}}\,.\left\{\dfrac{1}{\left\{1-\dfrac{2\,r\,(R+\rho)}{(R+\rho)^2+r^2}\,.\cos.\varphi\right\}^{\frac{3}{2}}} + \dfrac{1}{\left\{1+\dfrac{2\,r\,(R+\rho)}{(R+\rho)^2+r^2}\,.\cos.\varphi\right\}^{\frac{3}{2}}}\right\} \end{array}\right\} = o \ldots\ldots (B)$$

From this equation the value of F in terms of M may be found for any values of φ, the distances R, r and ρ being known; and if we suppose M constant during the observations, the variations in the intensity of the force F may be obtained from the observed variations in the value of φ.

If the angle φ does not differ from a right angle by more than 10° or even 20°, by expanding the several fractions, no sensible error will arise by limiting the series to a few of the

first terms, and we shall in these cases thus obtain a much more convenient equation for computation. Since

$$\frac{1}{(1-a\cos.\varphi)^{\frac{3}{2}}} = 1 + \frac{3}{2}\,.\,a\cos.\,\varphi + \frac{3\cdot5}{2\cdot4}a^2\cos.^2\varphi + \frac{3\cdot5\cdot7}{2\cdot4\cdot6}a^3\cos.^3\varphi + \frac{3\cdot5\cdot7\cdot9}{2\cdot4\cdot6\cdot8}a^4\cos.^4\varphi + \&c.$$

and

$$\frac{1}{(1+a\cos.\varphi)^{\frac{3}{2}}} = 1 - \frac{3}{2}\,.\,a\cos.\,\varphi + \frac{3\cdot5}{2\cdot4}a^2\cos.^2\varphi - \frac{3\cdot5\cdot7}{2\cdot4\cdot6}a^3\cos.^3\varphi + \frac{3\cdot5\cdot7\cdot9}{2\cdot4\cdot6\cdot8}a^4\cos.^4\varphi + \&c.$$

$$\frac{1}{(1-a\cos.\varphi)^{\frac{3}{2}}} + \frac{1}{(1+a\cos.\varphi)^{\frac{3}{2}}} = 2 + \frac{3\cdot5}{4}a^2\cos.^2\varphi + \frac{3\cdot5\cdot7\cdot9}{4\cdot6\cdot8}a^4\cos.^4\varphi + \&c.$$

So that the equation (B) will become

$$M - F\,.\left\{\begin{array}{l} \dfrac{R-\rho}{\left\{(R-\rho)^2+r^2\right\}^{\frac{3}{2}}}\,.\left\{2 + 3\,.\,5\,.\,\dfrac{r^2(R-\rho)^2}{\left\{(R-\rho)^2+r^2\right\}^2}\,.\cos.^2\varphi\right\} \\ -\dfrac{R+\rho}{\left\{(R+\rho)^2+r^2\right\}^{\frac{3}{2}}}\,.\left\{2 + 3\,.\,5\,.\,\dfrac{r^2(R+\rho)^2}{\left\{(R+\rho)^2+r^2\right\}^2}\,.\cos.^2\varphi\right\} \end{array}\right\} = o \quad \text{(C)}$$

neglecting the terms which contain the fourth and higher powers of cos. φ,

Taking one of the cases which I investigated, and from which the others do not differ very considerably, the values of the co-efficients of cos. φ in the denominators of the fractions in the equation (B) are .25691 and .15951; so that the greatest of the terms neglected would be

$$\frac{3\cdot5\cdot7\cdot9}{4\cdot6\cdot8}\times(.25691)^4.\cos.^4\varphi \text{ and } \frac{3\cdot5\cdot7\cdot9}{4\cdot6\cdot8}\times(.15951)^4\cos.^4\varphi.$$

Now, supposing that φ is 70°, if these terms are employed in determining the value of F, it will be 218.7705 . M, and 218.8184 . M, if they are neglected; making a difference of .0479 M, or only affecting the fifth figure in this extreme

case. If, instead of expanding the fractions, we computed them in the form which they have in the equation (B), we could hardly be supposed to obtain the *absolute* values of F more nearly than this; although in either case the relative values would be obtained to a much greater degree of accuracy. In the observations which I made, the values of ϕ were seldom much less than 80°, and in such cases the error would be considerably less. In an instance where ϕ was 82° 37′, the value of F was 222.5630 M, employing the terms containing $\cos.^4 \phi$, and 222.5640 M, neglecting them. Seeing then that no sensible error would arise from neglecting these terms, I have in all cases made use of the equation (C), for determining the values of F. I now proceed to the experiments which I made for this purpose.

On this occasion I made use of the same compass which I had already used in the greater part of the observations detailed in my former paper, and distinguished there as No. 1; the magnets were also the same that I had used with this compass. The length of the needle is very accurately 6 inches. In order to determine the distance between the points which I ought to consider as the poles of the needle, I fixed it at right angles to the meridian; and bringing another needle, freely suspended, near to it, I moved the centre of this needle along a line parallel to the axis of the first, and noted the points opposite to which the axis of the second was exactly in the magnetic meridian; these points I considered as the poles of the first needle. The distance between the points thus determined was 4.28 inches.

In my former paper I have stated the length of each of the magnets to be 12 inches; more accurately, the length of the

two joined together was 23.84 inches; so that the length of each might be taken to be very accurately 11.92 inches: they are .95 inch wide, and .375 inch thick. In all my observations the same magnet was always placed on the same side of the centre of the needle; so that in ascertaining the situations of their poles I distinguish one as the north, the other as the south magnet. The distances of the poles of the magnets from their ends, determined in the same manner as for the needle, were measured on each side, and a mean of the whole taken to obtain the distances between the poles; they were these:

	North Magnet.		South Magnet.	
	North Pole.	South Pole.	North Pole.	South Pole.
	0. 82 inch.	0.86 inch.	0.84 inch.	0. 77 inch.
	0. 81	0.86	0.84	0. 76
Mean	0.815	0.86	0.84	0.765

Taking half the sum of these, 1.64 inches, from the length of each magnet, we have 10.28 inches for the distance between the poles.

A meridian line being drawn on a firm table, standing on a stone floor, the compass was accurately adjusted on it, so that the needle pointed to zero on the graduated circle. The magnets were fixed at the bottoms of earthen pans, secured in such a way to rectangular pieces of board that their positions could not be accidentally changed, and projecting from these boards were small pieces of brass, on each of which a line was drawn to indicate the position of the axis of the magnet; the horizontal distance of the edge of each of the

projections nearest to the needle from the corresponding end of the magnet within the pan, was exactly 3 inches; I could therefore, in any instance, determine very accurately the distance of the centre of the magnet from that of the needle. The pans were placed on the table, so that the indexes on the pieces of brass coincided with the meridian line. Water was now poured into the pans, and the temperature of the magnets was varied by varying the temperature of the water. The temperature of each magnet was ascertained by a thermometer placed in the water, with its bulb resting on that pole of the magnet which was nearest to the centre of the needle. In my first observations I however made use of only one thermometer, which was moved, during them, from one magnet to the other. In Plate I. Fig. 1, an apparatus of the same nature, which I subsequently made use of, is represented. This differs from that employed in these experiments only in having the boxes containing the magnets made to slide on a ruler, whose axis being in the magnetic meridian, and the axes of the magnets adjusted in the boxes also in the meridian, they can be made to approach or recede from the needle, in that line, which saves considerable trouble in the adjustments when observations are to be made at different distances. Fig. 2 and 3 represent the plan and elevation of another apparatus which I had constructed for Mr. FOSTER, and which he has taken with him on the North-western Expedition, to enable him to make observations on the daily variation, particularly with a view of ascertaining the times of maximum east and west, and also of zero, should any of the stations at which he may find himself be favourable to the employment of such an ap-

Fig. 1.

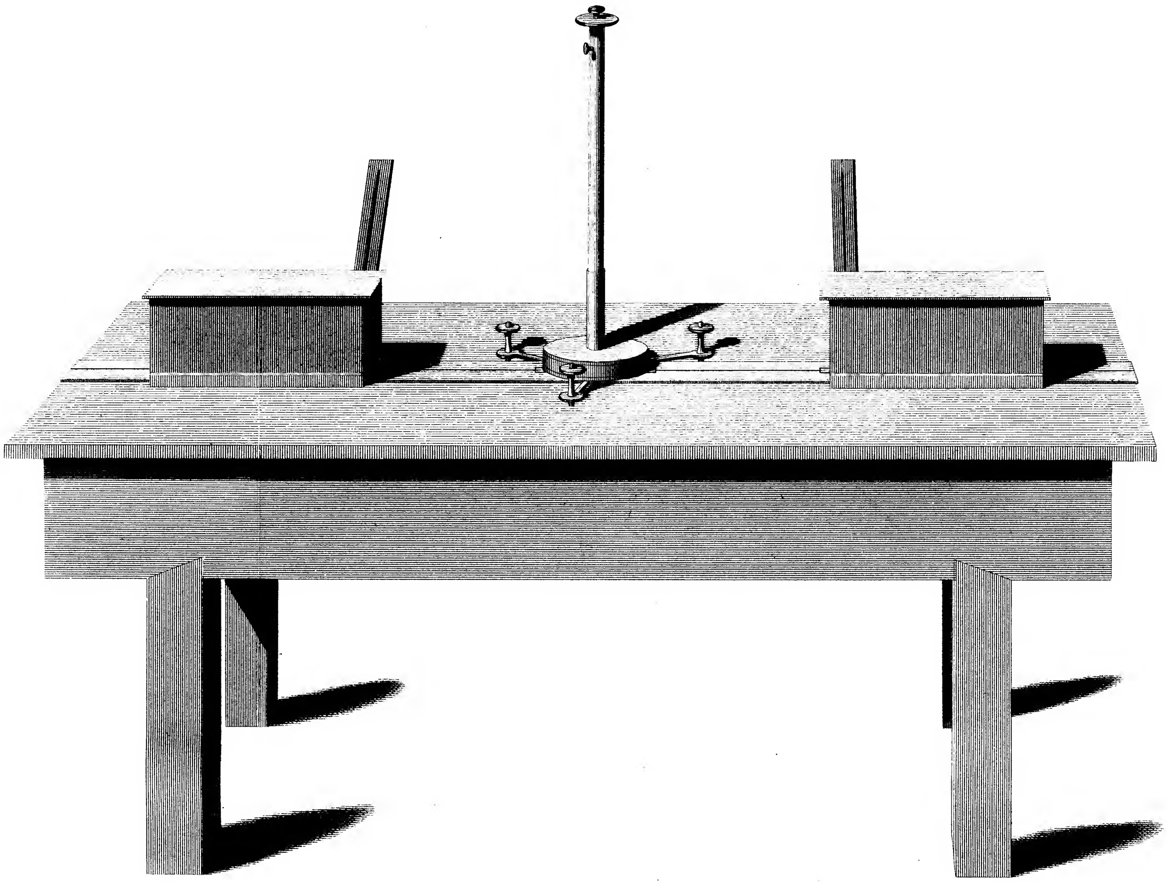


Fig. 2.

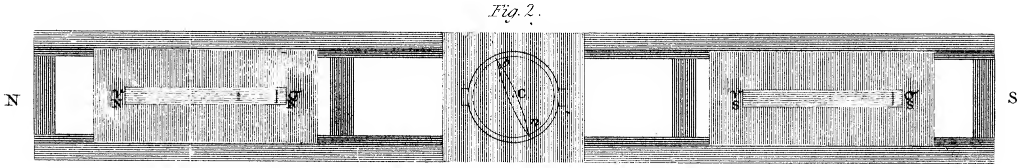
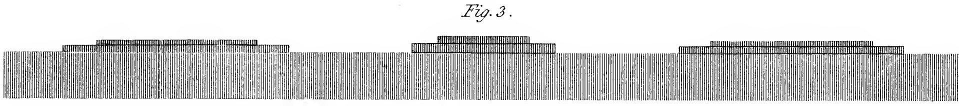


Fig. 3.



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paratus. N, S, (Fig. 2,) denote the ends of the instrument to be placed towards the magnetic north and south; *c*, the centre of the needle; *n* and *s*, its north and south *poles*; ν_N, σ_N, the north and south *poles* of the north magnet; ν_S, σ_S, the north and south *poles* of the south magnet: the magnets being fixed on boards which, sliding in grooves, may be made to approach or recede from the needle at pleasure.

In the observations which I first made on the effects of changes of temperature, the centres of the magnets were at the same distances from the centre of the needle as they were during the observations on the diurnal changes in the directions of the needle, which it was my object to reduce, and which will be given in the conclusion of this paper: this distance was 21.21 inches. We have therefore in this case $R = 21.21$ inches, and, from what I have before said, $r = 2.14$ inches, and $\varrho = 5.14$; if we substitute these values in the equation (C), it will become

$$M. - F. (.004690814 + .000829329 \cos. \phi) = 0. \qquad (\alpha)$$

Observing then the value of ϕ at any particular temperature of the magnets, by means of this equation I could readily obtain the corresponding value of F in terms of M; and by varying the temperature of the magnets, I obtained the variation of the intensity of their forces, corresponding to such change of temperature. The observations contained in the following table were made thus: I first noted the time, which is set down in the first column, and then the temperature of the north magnet; after which I placed the thermometer on the pole of the south magnet: I next observed the westerly point, at which the needle was held in equilibrio

by the terrestrial forces and those of the magnets, slightly agitating the needle, that it might the more readily assume the true position; from this it was led, by means of a very small and weak magnet, held on the outside of the compass-box, towards the easterly point of equilibrium, which was observed in the same manner; and from this it was led in the same way towards the southerly point, which, however, was not observed with an intention of deducing any thing by means of the equation (α), which was not calculated for such a value of φ. After these observations of the points of equilibrium, the temperature of the south magnet being observed, the time set down in the seventh column, at which the observations concluded, was noted. The temperature of the water in the pans was now increased or diminished, according to circumstances, by the addition of other water, and the pans covered over, to prevent any rapid changes of temperature during the observations: after allowing a short time for the magnets to acquire the temperature of the water, the observations were repeated. To prevent any ambiguity, with regard to the time indicated being morning or evening, I have, except when otherwise expressed, adopted the astronomical division of the day, from noon to noon. The scale made use of for the temperature was in all cases that of FAHRENHEIT.

Table of the positions of the **Points** *of* **Equilibrium**, *corresponding to different* **Temperatures** *of the* **Magnets** *retaining a* **Magnetic Needle** *in equilibrio.* **6th June, 1823.**

Time of commencing observation.	Temperature of N. Magnet.	Points of Equilibrium.			Temperature of S. Magnet.	Time of concluding observation.	Mean temperature of the Magnets.	$10^h\ 15^m$ Barom. 30.12, Therm. attached 60.25
		West.	East.	South.				
h. m.	°	° ′	° ′	° ′	°	h. m.	°	
7 54	62.0	82 44	82 30	0 12W	62.1	8 01	62.05	
8 10	59.3	86 00	84 50	0 12	58.8	8 17	59.05	
8 31	79.0	74 40	74 56	0 12	76.3	8 35	77.65	
8 40	75.0	76 02	75 54	0 12	73.0	8 44	74.00	
8 52	71.0	77 30	77 24	0 10	70.3	8 56	70.65	
9 11	67.3	79 16	78 52	0 14	67.0	9 16	67.15	
9 34	63.8	80 42	80 50	0 18	63.8	9 40	63.80	
9 53	62.0	81 50	82 16	0 16	62.1	10 00	62.05	

Taking half the sum of the easterly and westerly arcs for the value of φ, and substituting them successively for φ in the equation (α), I obtain the values of $\frac{F}{M}$ corresponding to the respective mean temperatures of the magnets. These I have arranged in the following table; placing in the second column the differences of the successive temperatures, and in the fifth the corresponding differences in the values of $\frac{F}{M}$; these, divided by the numbers in the second column, will give the variation of the value of $\frac{F}{M}$, corresponding to a change in the temperature of the magnets of 1° on FAHRENHEIT's scale: these variations in the values of $\frac{F}{M}$ are contained in the last column of the table, and are denoted by $\Delta \,.\, \frac{F}{M}$.

Table of the Magnetic Intensities corresponding to different Temperatures of the Magnets.

Mean temperature of the Magnets.	Diff. of Temp. in successive observations.	Mean of the observed values of φ.	Magnetic Intensity or values of $\frac{F}{M}$.	Diff. of successive values of $\frac{F}{M}$.	Variation of $\frac{F}{M}$ for 1° Fah. or $\Delta \cdot \frac{F}{M}$.
62°.05		82° 37′	212.5620		
59.05	− 3.00	85 25	212.9423	+0.3803	0.1268
77.65	+18.60	74 48	210.6228	−2.3195	0.1247
74.00	− 3.65	75 58	210.9892	+0.3664	0.1004
70.65	− 3.35	77 27	211.4178	+0.4286	0.1279
67.15	− 3.50	79 04	211.8353	+0.4175	0.1193
63.80	− 3.35	80 46	212.2167	+0.3814	0.1138
62.05	− 1.75	82 03	212.4640	+0.2473	0.1413

The differences in the deduced values of the variation of $\frac{F}{M}$ for a change of temperature in the magnets of 1° in the last column, are not greater than we may suppose to have arisen from small inaccuracies in the observations, or slight changes in the terrestrial intensity during the time in which they were made; the latter indeed appear to have taken place, since, at the same temperature, the value of φ was 82° 37′ at the beginning of the observations, and 82° 03′ at their conclusion. The value 0.1247 deduced from the observations at the temperatures 59.05 and 77.65 I should consider as nearest the truth, since whatever may have been the errors, the divisor is here larger than in any other case; and, in taking a mean, this value should be taken with the mean of all the others: the contrary may be said of the value 0.1413, which should have only half the weight of any of the others. I therefore first take in this manner the mean of all the values excluding 0.1247, and then the mean of this

mean and 0.1247, and I thus get .1226 as the mean variation of the intensity of the magnets for a change in their temperature of 1°, between the temperatures 59.05 and 77.65, an increase of temperature always causing a decrease of intensity, and *vice versa*.

In the results in the last column of this table there are no marked indications of an increase in the values of $\Delta . \frac{F}{M}$ arising from an increase of the temperature at which the observations were made. Having afterwards, when I carried the observations to a greater extent in the scale of temperature, clearly ascertained that this was the case, I determined therefore not to take the mean of the values of $\Delta . \frac{F}{M}$, as I have here pointed out, but as I had made observations at every convenient opportunity, to take out from them, in the first place, all the values of $\Delta . \frac{F}{M}$, where the mean between the temperatures from which they were derived agreed nearly with the lowest temperature of the observations which it was my object to reduce; in the same manner, to take those which agreed most nearly with the mean temperature to which these observations were to be reduced; and likewise those agreeing with their highest temperature: taking then the mean of each of these, from these three means, I derived a value of $\Delta \frac{F}{M}$, from which I determined the variation of the angle ϕ, corresponding to any change of temperature. I have mentioned this here, that my reason for giving so many of the observations may be apparent. Observations, precisely similar to the preceding, were made on the 7th of June: they are contained in the following table.

Table of the positions of the Points of Equilibrium corresponding to different Temperatures of the Magnets retaining a Magnetic Needle in equilibrio, 7th June.

Time of commencing observation.	Temperature of N. Magnet.	Points of Equilibrium. West.	East.	South.	Temperature of S. Magnet.	Time of concluding observation.	Mean temperature of the Magnets.	
h. m.	°	° ′	° ′	° ′	°	h. m.	°	$10^h\ 50^m$ Barom 30.12, Therm. att. 60.50
9 50	57.0	83 18	83 16	0 10W	57.0	9 53	57.00	
10 04	66.3	78 16	78 04	0 16	67.7	10 07	67.00	
10 15	71.0	76 22	76 10	0 14	70.7	10 18	70.85	
10 27	75.0	74 36	74 42	0 12	75.0	10 31	75.00	
10 44	60.0	81 18	80 26	0 20	61.0	10 47	60.50	

Previous to making these observations I had slightly changed the distances of the magnets from the centre of the needle: the distances of their nearest ends were now 15.26 inches, or that of their centres 21.22 inches from the needle's centre. Substituting this value of R in the equation (C) it becomes

$$M - F\,(.004683954 + .000827265 \cos.^2 \varphi) = o; \qquad (\alpha_1)$$

and from this I calculated the following table.

Table of the Magnetic Intensities corresponding to different Temperatures of the Magnets.

Mean temperatures of the Magnets.	Diff. of Temp. in successive observations.	Mean of the observed values of φ.	Magnetic Intensity or value of $\frac{F}{M}$.	Diff. of successive values of $\frac{F}{M}$.	Variation of $\frac{F}{M}$ for 1° Fah. or $\Delta . \frac{F}{M}$.
°		° ′			
57.00	+10.00	83 17	212.9803	−1.0594	0.1059
67.00	+ 3.85	78 10	211.9209	−0.5302	0.1377
70.85	+ 4.15	76 16	211.3907	−0.5059	0.1219
75.00	−14.50	74 39	210.8848	+1.6641	0.1148
60.50		80 52	212.5489		

After these observations the magnets were wiped dry, and their poles of contrary names joined by bars of soft iron: to this circumstance I attribute the increase which, when next I used them, I found had taken place in their intensities. In the observations subsequent to these, I made use of two thermometers, one for each magnet, and observed the temperatures of both magnets at the beginning and at the conclusion of the observation.

Table of the positions of the Points of Equilibrium corresponding to different Temperatures of the Magnets retaining a Magnetic Needle in Equilibro. **13th of June.**

Time of commencing observation.	Temperature of		Points of Equilibrium.			Temperature of		Time of concluding observation.	Mean Temperature of the Magnets.	$8^h 40^m$ { Barom. 29.93 / Therm. att. 65.66
	N. Mag.	S. Mag.	West.	East.	South.	N. Mag.	S. Mag.			
h. m.	°	°	° ′	° ′	° ′	°	°	h. m.		
7 12	63.0	62.6	80 28	80 28	0 18 E	63.0	62.6	7 14	62.80	
7 35	61.1	61.0	81 12	81 16	0 16	61.2	61.0	7 40	61.08	
7 55	71.1	71.1	75 36	75 44	0 18	71.0	71.0	8 00	71.05	
8 26	66.2	65.8	77 40	77 48	0 18	66.1	65.7	8 32	65.95	

I have just mentioned that, on making these observations, I found the intensities of the magnets increased: on this account I was under the necessity of increasing their distances from the needle. The distances of their nearest ends from the centre of the needle were in this case 15.45 inches, or of their centres 21.41 inches: this value of R being substituted in the equation (C) gives

$$M - F\,(.004553604 + .0007880523 \cos.^2 \phi) = o. \qquad (\alpha_2).$$

As before, I calculate the following table from this equation.

Table of the Magnetic Intensities corresponding to different Temperatures of the Magnets.

Mean Temperature of the Magnets.	Diff. of Temp. in successive observations.	Mean of the observed values of φ.	Magnetic Intensity or value of $\frac{F}{M}$.	Diff. of successive values of $\frac{F}{M}$.	Variation of $\frac{F}{M}$ for 1° Fah. or $\Delta \cdot \frac{F}{M}$.
62°.80		80° 28′	218.5687		
	−1.72			+0.1582	0.0920
61.08		81 14	218.7269		
	+9.97			+1.4255	0.1430
71.05		75 40	217.3014		
	−5.10			+0.6026	0.1182
65.95		77 44	217.9040		

There is only one, the first, of the values of $\Delta \cdot \frac{F}{M}$, which differs much from those already obtained, but the difference of the temperatures in the observations from which it is derived is so small, that any errors would be rendered very sensible; and if the thermometers happened not to indicate the precise temperatures of the magnets at the times of observation, it would be quite sufficient to account for this discrepancy.

In his paper on the daily variation of the horizontal and dipping needles under a reduced directive power, Mr. BARLOW has described some anomalies which he observed between the daily changes in the direction of a needle when placed in the house and when in the open air, and also the steps which he took to discover their cause. He mentions, "that in certain positions of the needle towards the east and west, the daily motion, although it proceeded with the same determinate uniformity in both cases, yet it took place in different directions; passing in the one instance from the east, or west, towards the south, and in the other towards the north, at the

same corresponding hours of the day, the motion in both instances being equally distinct, regular, and progressive."* These anomalies, I also noticed, although, as I have mentionod in my former paper, I did not find the reversion, in the directions in the two cases, to take place with the same regularity and uniformity that Mr. BARLOW observed it to have. In that paper I also stated my opinion, that these anomalies had arisen from the difference in the changes of temperature in the magnets when in doors and when in the open air, and that the observations in the two cases would be found to agree when they were freed from the influence of difference of temperature in the magnets.

As I had already made observations in doors, in which I noted the temperature of the magnets, it was now my intention to make corresponding observations in the open air, in order that by reducing the obervations to the same standard of temperature, their agreement or disagreement might be put beyond doubt. For this purpose the whole apparatus was placed in my garden, exposed to the sun and air, on a table having its legs driven firmly into the ground; and for several days I observed, at stated intervals, the positions of the points of equilibrium; when I had an opportunity I also made experiments, similar to the preceding, for the purpose of determining the value of $\Delta \frac{F}{M}$, to be applied to the correction of the observations in doors and in the open air.

On adjusting the magnets to the needle, I again found that

* In the Postscript to this paper, Mr. BARLOW, to whom I had communicated my views with regard to the effects of temperature, refers to the experiments which I had made, for the explanation of these apparent anomalies.

their intensities had increased, owing, I consider, to the same circumstance as before, and I therefore increased their distances from the needle; but after making the first days observations, and comparing them with those made in doors, I found it necessary slightly to diminish these distances, in order that, at the same temperature of the magnets, the situations of the points of equilibrium might more nearly agree in the two cases. During the observations of the first day, the distance of the nearest ends of the magnets from the centre of the needle were 15.62 inches: so that the value of R is here 21.58 inches, and the equation C becomes,

$$M - F\,(.004441190 + .0007549085 \cos.^2 \varphi) = 0 \qquad (\alpha_3)$$

The observations are contained in the following table.

Table of the positions of the Points of Equilibrium corresponding to different Temperatures of the Magnets retaining a Magnetic Needle in Equilibrio. 17th and 18th June.

Time of commencing observation.		Temperature of the Magnets.		Points of Equilibrium.			Temperature of the Magnets.		Time of concluding observation.	Mean Temperature of the Magnets.	Barom.	Therm. attached.
		North.	South.	West.	East.	South.	North.	South.				
June	h. m	°	°	° ′	° ′	° ′	°	°	h. m.	°		
17	19 27	49.6	48.8	79 58	80 46	0 42 E	49.8	49.0	19 32	49.30		
	19 53	60.25	60.25	75 24	75 46	0 32 E	60.25	60.25	19 56	60.25		
	20 15	68.4	68.6	72 02	72 40	0 24 E	67.8	68.2	20 19	68.25		
	20 36	74.9	75.0	69 36	70 08	0 24 E	74.2	74.3	20 41	74.60		
	21 02	61.8	62.0	74 12	74 24	0 14 E	61.5	61.7	21 06	61.75		
	21 26	74.0	74.2	70 06	70 24	0 08 E	73.4	73.6	21 30	73.80	30.29	55.75
18	7 36	55.7	55.5	75 00	75 06	0 00	55.7	55.4	7 40	55.58		
	8 00	66.2	66.0	70 58	71 28	0 02 E	66.0	65.8	8 04	66.00		
	8 25	73.8	73.8	68 12	68 52	0 02 E	73.4	73.4	8 28	73.60		
	8 51	56.8	57.4	74 38	74 44	0 02 E	56.4	57.0	8 56	56.90	30.20	56.00

From these I calculate the following table by means of the equation (α_3).

Table of the Magnetic Intensities corresponding to different Temperatures of the Magnets.

Mean Temperature of the Magnets.	Diff. of Temp. in successive observations.	Mean of the observed values of φ.	Magnetic Intensity, or value of $\frac{F}{M}$.	Diff. of successive values of $\frac{F}{M}$.	Variation of $\frac{F}{M}$ for 1° Fah or $\Delta . \frac{F}{M}$.
49°.30		80° 22′	224.0981		
60.25	+10.95	75 35	222.8171	−1.2810	0.1179
68.25	+ 8.00	72 21	221.7046	−1.1125	0.1391
74.60	+ 6.35	69 52	220.7198	−0.9848	0.1551
61.75	−12.85	74 18	222.3967	+1.6769	0.1305
73.80	+12.05	70 15	220.8778	−1.5189	0.1260
55.58		75 03	222.6462		
66.00	+10.42	71 13	221.2655	−1.3807	0.1315
73.60	+ 7.60	68 32	220.1532	−1.1123	0.1461
56.90	−16.70	74 39	222.5145	−2.3613	0.1314

After making these obsevations, the distances of the magnets from the needle were slightly diminished, for the reasons I have already mentioned: their nearest ends were now 15.56 inches from the centre of the needle, or the value of R was 21.52 inches. By substituting this value in the equation C, it becomes

$$M - F . (.004480432 + .0007664093 \cos.^2 \varphi) = o. \qquad (\alpha_4)$$

The observations which I made with the magnets at this distance from the needle, and the results which I obtain from them, are contained in the two following tables.

Table of the positions of the Points of Equilibrium corresponding to different temperatures of the Magnets retaining a Magnetic Needle in equilibrio. 18th, 19th, 20th, 22nd June.

Time of commencing observation.		Temperature of the Magnets.		Points of Equilibrium.			Temperature of the Magnets.		Time of concluding observation.	Mean Temperature of the Magnets.	Barom.	Therm. attached.
		North.	South.	West.	East.	South.	North.	South.				
June	h. m.	°	°	° ′	° ′	°	°	°	h. m.	°		°
18	19 24	55.2	55.2	85 18	84 24	0 20 E	55.6	55.6	19 32	55.40	30.23	57.10
	19 47	74.0	74.2	75 16	74 24	0 26 E	73.5	73.5	19 51	73.80		
	20 08	55.5	55.3	85 36	84 32	0 14 E	55.5	55.3	20 14	55.40		
19	7 25	56.0	55.0	83 08	82 06	0 06 E	55.8	55.0	7 30	55.45		
	7 52	64.6	64.3	77 38	77 20	0 00	64.3	64.0	7 56	64.30	30.17	55.3
	8 16	74.4	74.2	73 28	72 58	0 00	73.5	73.5	8 21	73.90		
	8 40	64.7	65.0	77 44	77 06	0 12 W	63.7	63.7	8 47	64.28		
	9 01	55.6	55.8	82 34	81 30	0 12 W	55.3	55.5	9 04	55.55	30.17	55.7
	19 25	55.2	54.8	84 12	83 02	0 18 E	55.5	55.1	19 29	55.15	30.11	56.75
	19 50	67.3	66.5	77 26	76 44	0 22 E	66.8	66.4	19 55	66.75		
20	17 29	51.3	50.0	85 16	85 14	0 14 E	51.3	50.0	17 34	50.65	30.10	60.4
	17 50	56.8	55.0	81 46	81 28	0 26 E	56.6	54.8	17 55	55.80		
	18 14	51.7	51.1	84 44	84 38	0 16 E	51.6	51.1	18 19	51.35		
	18 40	57.6	57.0	80 42	80 46	0 20 E	57.4	56.8	18 46	57.20		
22	18 01	54.7	53.7	82 52	82 46	0 10 E	54.5	53.4	18 06	54.08	30.16	55.3
	18 22	52.0	51.0	85 10	85 14	0 10 E	51.6	50.8	18 28	51.35		
	18 48	56.3	56.0	82 08	81 40	0 14 E	55.8	55.7	18 53	55.94		

Table of the Magnetic Intensities corresponding to different Temperatures of the Magnets.

Mean Temperature of the Magnets.	Diff. of Temp. in successive observations.	Mean of the observed values of φ.	Magnetic intensity or value of $\frac{F}{M}$.	Diff. of successive values of $\frac{F}{M}$.	Variation of $\frac{F}{M}$ for 1° Fah. or $\Delta . \frac{F}{M}$.
°		° ′			
55.40		84 51	222.8859		
73.80	+18.40	74 50	220.6103	−2.2756	0.1237
55.40	−18.40	85 04	222.9113	+2.3010	0.1251
55.45		82 37	222.5640		
64.30	+ 8.85	77 29	221.4144	−1.1496	0.1299
73.90	+ 9.60	73 13	220.0549	−1.3595	0.1415
64.28	− 9.62	77 25	221.3962	+1.3413	0.1394
55.55	− 9.73	82 02	222.4610	+1.0648	0.1220
55.15		83 37	222.7217		
66.75	+11.60	77 05	221.3013	−1.4204	0.1224
50.65		85 15	222.9322		
55.80	+ 5.15	81 37	222.3848	−0.5474	0.1063
51.35	− 4.45	84 41	222.8660	+0.4712	0.1059
57.20	+ 5.85	80 44	222.2080	−0.6580	0.1125
54.08		82 49	222.5974		
51.35	− 2.73	85 12	222.9263	+0.3289	0.1203
55.94	+ 4.59	81 54	222.4377	−0.4886	0.1064

After having made the preceding observations, and concluded those on the diurnal changes in the points of equilibrium, I proposed applying the balance of torsion, as another means of determining the variations in the magnetic intensities, arising from changes in the temperatures of the magnets; but in my first observations with this instrument, there were such discrepancies, arising from the over torsion of the wire in consequence of its want of elasticity, being silver and too fine for the weight of the needle, and likewise too short, that, although they pointed out very clearly the same general results which I afterwards obtained from unexceptionable observations, I would not make use of them for determining a mean value of $\Delta . \frac{F}{M}$ to be applied to the correction of the observations on the diurnal changes, for the variation in the temperature of the magnets. As a considerable time intervened before I had an opportunity of repeating these experiments, and in making them, I had, by increasing the temperature of the magnets beyond a certain point, permanently destroyed a portion of their intensities, I considered it better to obtain the mean value of $\Delta . \frac{F}{M}$, which was requisite, from the results of the experiments made more nearly at the same time as the observations which it was my object to reduce. I therefore determined this value from the preceding results.

The temperatures of the magnets in the observations on the daily changes of the points of equilibrium were, with a few exceptions above and below, comprised between 54° and 65°, and I determined the mean value of $\Delta \frac{F}{M}$ to be applied to the correction of these observations in this manner: from

the preceding results I first took those values of $\Delta \frac{F}{M}$ derived from observations where the mean of the temperatures was near to 65°, and from these obtained a mean value of $\Delta . \frac{F}{M}$ when the mean temperature of the magnets was nearly 65°: in like manner I obtained a mean value of $\Delta . \frac{F}{M}$ when the mean temperature of the magnets was nearly 60°, and also when nearly 54°: taking a mean of these three means, I obtained a value of $\Delta . \frac{F}{M}$, which could not be sensibly different from its true value in any of the observations which were to be corrected. These are collected in the following table.

Table of Results for obtaining the Mean value of $\Delta . \frac{F}{M}$.

Mean Temperature 65° nearly.

Date.	Temperatures.		Mean.	Value of $\Delta \frac{F}{M}$
June	°	°	°	
6	62.05	67.15	64.600	.1233
13	61.08	71.05	66.065	.1430
17	60.25	68.25	64.250	.1391
17	61.75	73.80	67.775	.1260
18	56.90	73.60	65.250	.1314
18	55.40	73.80	64.600	.1237
18	55.40	73.80	64.600	.1251
19	55.45	73.90	64.675	.1360
19	55.55	73.90	64.725	.1311
		Mean	65.171	.13097

Mean Temperature 60° nearly.

Date.	Temperatures.		Mean.	Value of $\Delta . \frac{F}{M}$.
June	°	°	°	
6	59.05	62.05	60.550	.1268
17	49.30	68.25	58.775	.1263
18	55.58	66.00	60.790	.1315
19	55.45	64.30	59.875	.1299
19	55.55	64.28	59.915	.1220
19	55.15	66.75	60.950	.1224
		Mean	60.143	.12648

Mean Temparature 54° nearly.

Date.	Temperatures.		Mean.	Value of $\Delta . \frac{F}{M}$.
June	°	°	°	
17	49.30	60.25	54.775	.1179
20	50.65	55.80	53.225	.1063
20	51.35	55.80	53.575	.1059
20	51.35	57.20	54.275	.1125
22	51.35	54.08	52.715	.1203
22	51.35	55.94	53.645	.1064
		Mean	53.701	.11155

Mean value of $\Delta . \frac{F}{M}$, to be applied in correcting the observations on the Diurnal changes in the positions of the Points of Equilibrium } 0.12300

To apply the value of $\Delta . \frac{F}{M}$, thus determined, to the correction of the observed directions of the needle, for the changes which took place in the temperature of the magnets, let $\Delta \phi$ be the increment of the azimuth of the needle corres-

ponding to the increment Δ F of the intensity of the magnets. When therefore F becomes $F + \Delta F$, putting the equation (C) in the form

$$M - (P + Q \cdot \cos.^2 \phi) \cdot F = o,$$

it becomes

$$M - \{P + Q \cdot \cos.^2 (\phi + \Delta \phi)\} (F + \Delta F) = o,$$

whence

$$\cos.^2 (\phi + \Delta \phi) = \frac{1}{Q} \cdot \left\{\frac{M}{F + \Delta F} - P\right\}. \qquad \text{(E)}$$

This formula, though sufficiently simple, is not in the most convenient form for calculating the values of $\Delta \phi$, corresponding to different values of ϕ, owing to the common tables of logarithms giving only seven places of figures. The values of P and $\frac{M}{F + \Delta F}$ agree in the first two or three figures, so that there will remain only five figures towards the beginning of the table, and four figures towards the end of it, from which the values of $\phi + \Delta \phi$ are to be derived, consequently they cannot be calculated to the greatest accuracy. But if $\frac{M}{F + \Delta F}$ be expanded, the first figure of $\frac{M}{F + \Delta F} - P$ being in the 5th place of decimals, the first figure of $\frac{(\Delta F)^2}{F^3}$ will be in the 9th place, and the first figure of $\frac{(\Delta F)^3}{F^4}$ will be in the 13th place; and therefore we should obtain the value of $\frac{M}{F + \Delta F} - P$ true to the 11th place of decimals, or true to 7 places of figures when we neglect the term $\frac{(\Delta F)^3}{F^4}$. Now in the cases which I had to compute, the first two figures in the value of $\frac{(\Delta F)^2}{F^3}$ were the same for all the arcs, and conse-

quently by using these, the value of $\frac{M}{F+\Delta F}-P$ for the determination of $\cos.^2(\phi+\Delta\phi)$ would be true to the 6th figure, which would give $\phi+\Delta\phi$ to the tenth of a second. Such a degree of accuracy may appear quite uncalled for by the nature of the observations, but from the manner which I adopted for correcting them, it was necessary to guard against any accumulation of error.

From what I have said, we have

$$\cos.^2(\phi+\Delta\phi)=\frac{1}{Q}\left\{\frac{M}{F}-M.\left(\frac{\Delta F}{F^2}-\frac{(\Delta F)^2}{F^3}\right)-P\right\};$$

but $$\frac{M}{F}=P+Q\cos.^2\phi,$$

and therefore,

$$\cos.^2(\phi+\Delta\phi)=\frac{1}{Q}\left\{Q\cos.^2\phi+\frac{M(\Delta F)^2}{F^3}-\frac{M.\Delta F}{F^2}\right\}. \qquad \text{(G)}$$

Having, as we have seen, determined by observation ΔF in terms of M, and $\frac{M}{F}$, being computed from the equation (C), for any angle ϕ, the value of $\Delta\phi$ would be readily computed from this formula: that is, we could obtain from it the correction to be made in any observed angle, for a change of 1° in the temperature of the magnets, whether that temperature were increasing or decreasing, only observing that ΔF is minus for an increase of temperature, and plus for a decrease.

The method which I have adopted for reducing the observed values of ϕ to what they would have been, had the temperature of the magnets been constant, is this: the observed values of ϕ being comprised between 74° and 86°, I computed the values of $\Delta\phi$, both plus and minus, at inter-

vals of 30 minutes, from 74° to 86°, by means of the formula (G): from these and their several orders of differences, I interpolated the values of $\Delta\,\phi$ at intervals of 6 minutes: forming these, with their differences, into tables, I obtained from them, by inspection, the value of $\Delta\,\phi$ corresponding to any observed angle: adding the plus value of $\Delta\,\phi$ to the observed angle, when the temperature of the magnets was above the mean temperature to which the observations were to be reduced, I obtained the value of ϕ at a temperature of the magnets one degree lower than that observed: proceeding in the same manner with this corrected value of ϕ, I obtained another value at a temperature one degree lower than the last, or two degrees below the observed temperature: with this I proceeded again in the same manner, and so on, until the observed value of ϕ was reduced to its value at the standard temperature of the magnets. If the observed temperature was below the mean temperature, I successively subtracted the different minus values of $\Delta\,\phi$ to obtain the corrected value of ϕ. This will perhaps be better understood when I come to the observations and their corrections; but I thought it necessary to explain the use which I made of these tables previous to giving them.

In the observations which I made within doors on the daily variation in the positions of the points of equilibrium, the distances of the nearest ends of the magnets from the centre of the needle were 15.21 inches, or the distances of their centres from the centre of the needle 21.21 inches; so that, as we have before seen, the equation (C) here becomes

$$M - (.004690814 + .000829329 \cos.^2 \phi).\ F = o; \qquad (\alpha)$$

consequently the equation (G) becomes

$$\cos.^2(\phi+\Delta\phi)=\frac{1}{.000829329}\times\left\{.000829329\cos.^2\phi+.0000000016\right.$$
$$\left.\mp.123\times(.004690814+.000829329\cos.^2\phi)^2\right\}=o;\ \ldots.(\gamma)$$

.0000000016, being the value of $\frac{M.(\Delta F)^2}{F^2}$ in all the values of ϕ for which I had to compute; and .123 the value of $\Delta.\frac{F}{M}$ already found: the upper sign to be used when $\Delta.\frac{F}{M}$ is plus, or when the observed temperature of the magnets is above the mean temperature to which the observations are to be reduced, and the lower sign, when $\Delta\cdot\frac{F}{M}$ is minus.

This formula is not so ill adapted for calculation as it may at first sight appear, since for each value of ϕ it is only necessary to refer to the tables eight times to obtain the values both of $\phi+\Delta\,\phi$ and $\phi-\Delta_1\,\phi$, or of ϕ_1 and ϕ_{-1}.

The values of ϕ, in the observations in doors, being comprised between 77° and 86°, I calculated the two following tables as the basis of the tables by which these observations were to be corrected, for the difference between the observed temperature of the magnets and the standard temperature.

1. *Table of the* increments *in the Azimuths of the Points of Equilibrium corresponding to a* decrement *of* 1° *in the Temperature of the Magnets, with their several orders of differences, calculated at intervals of* 30′ *in the Azimuths from* 77° *to* 86°*: the distances of the centres of the Magnets from the centre of the Needle being* 21.21 *inches.*

φ	$\Delta\varphi$	$\Delta^2\varphi$	$\Delta^3\varphi$	$\Delta^4\varphi$	$\Delta^5\varphi$	$\Delta^6\varphi$	$\Delta^7\varphi$
° ′	′	′	′	′	′	′	′
77 00	26.455	0.988					
30	27.443	1.080	0.092	0.012			
78 00	28.523	1.184	0.104	0.016	0.004		
30	29.707	1.304	0.120	0.020	0.004		
79 00	31.011	1.444	0.140	0.024	0.004		
30	32.455	1.608	0.164	0.027	0.003		
80 00	34.063	1.799	0.191	0.035	0.008		
30	35.862	2.025	0.226	0.047	0.012		
81 00	37.887	2.298	0.273	0.064	0.017		
30	40.185	2.635	0.337	0.080	0.016	0.013	
82 00	42.820	3.052	0.417	0.109	0.029	0.021	
30	45.872	3.578	0.526	0.159	0.050	0.025	
83 00	49.450	4.263	0.685	0.234	0.075	0.057	0.032
30	53.713	5.182	0.919	0.366	0.132	0.118	0.061
84 00	58.895	6.467	1.285	0.616	0.250	0.328	0.210
30	65.362	8.368	1.901	1.194	0.578	0.979	0.651
85 00	73.730	11.463	3.095	2.751	1.557		
30	85.193	17.309	5.846				
86 00	102.502						

2. *Table of the* decrements *in the Azimuths of the Points of Equilibrium corresponding to an* increment *of* 1° *in the Temperature of the Magnets, with their several orders of differences, calculated at intervals of* 30′ *in the Azimuths from* 77° *to* 86°: *the distances of the centres of the Magnets from the centre of the Needle being* 21.21 *inches.*

φ	$\Delta\varphi$	$\Delta^2\varphi$	$\Delta^3\varphi$	$\Delta^4\varphi$	$\Delta^5\varphi$
° ′	′	′	′	′	′
77 00	25.675	0.890	0.073	0.011	0.000
30	26.565	0.963	0.084	0.011	0.002
78 00	27.528	1.047	0.095	0.013	0.001
30	28.575	1.142	0.108	0.014	0.002
79 00	29.717	1.250	0.122	0.016	0.004
30	30.967	1.372	0.138	0.020	0.004
80 00	32.339	1.510	0.158	0.024	0.007
30	33.849	1.668	0.182	0.031	0.008
81 00	35.517	1.850	0.213	0.039	0.004
30	37.367	2.063	0.252	0.043	0.010
82 00	39.430	2.315	0.295	0.053	0.018
30	41.745	2.610	0.348	0.071	0.018
83 00	44.355	2.958	0.419	0.089	0.020
30	47.313	3.377	0.508	0.109	0.027
84 00	50.690	3.885	0.617	0.136	0.046
30	54.575	4.502	0.753	0.182	
85 00	59.077	5.255	0.935		
30	64.332	6.190			
86 00	70.522				

By means of the values of $\Delta\,\varphi$ and their several orders of differences, contained in these tables, interpolating in the usual manner, I calculated the following tables.

I. *Table of the* increments *in the Azimuths of the Points of Equilibrium corresponding to a* decrement *of* 1° *in the Temperature of the Magnets, calculated at intervals of* 6′ *in the Azimuths from* 77° *to* 86°*; the distances of the centres of the magnets from the centre of the needle being* 21.21 *inches: to be applied to the correction of the observed Azimuths, when the Observed Temperature of the Magnets is* above *the Mean Temperature to which the observations are to be reduced.*

φ	77°		78°		79°		80°		81°	
	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.
′	′		′		′		′		′	
00	26.455	.191	28.523	.228	31.011	.277	34.063	.343	37.887	.436
06	.646	.194	.751	.232	.288	.283	.406	.351	38.323	.447
12	.840	.197	.983	.237	.571	288	.757	.360	.770	.459
18	27.037	.201	29.220	.241	.859	.295	35.117	.368	39.229	.471
24	.238	.205	.461	.246	32.154	.301	.485	.377	.700	.485
30	.443	.209	.707	.250	.455	.308	.862	.386	40.185	.498
36	.652	.212	.957	.255	.763	.315	36.248	.395	.683	.512
42	.864	.216	30.212	.261	33.078	.322	.643	.405	41.195	.527
48	28.080	.220	.473	.266	.400	.328	37.048	.414	.722	.541
54	.300	.223	.739	.272	.728	.335	.462	.425	42.263	.557
60	.523		31.011		34.063		.887		.820	

φ	82°		83°		84°		85°	
	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.
′	′		′		′		′	
00	42.820	.574	49.450	.791	58.895	1.173	73.730	1.985
06	43.394	.591	50.241	.820	60.068	1.228	75.715	2.120
12	43.985	.609	51.061	.851	61.296	1.288	77.835	2.272
18	44.594	.629	51.912	.883	62.584	1.354	80.107	2.445
24	45.223	.649	52.795	.918	63.938	1.424	82.552	2.641
30	45.872	.670	53.713	.955	65.362	1.499	85.193	2.865
36	46.542	.691	54.668	.994	66.861	1.579	88.058	.120
42	47.233	.714	55.662	1.034	68.440	1.665	91.178	3.411
48	47.947	.739	56.696	1.077	70.105	1.759	94.589	3.753
54	48.686	.764	57.773	1.122	71.864	1.866	98.342	4.160
60	49.450		58.895		73.730		102.502	

II. *Table of the* decrements *in the Azimuths of the Points of Equilibrium corresponding to an* increment *of* 1° *in the Temperature of the Magnets, calculated at intervals of* 6′ *in the Azimuths from* 77° *to* 86°; *the distances of the centres of the Magnets from the centre of the Needle being* 21.21 *inches: to be applied to the correction of the observed Azimuths when the observed Temperature of the Magnets is* below *the Mean Temperature to which the observations are to be reduced.*

φ	77°		78°		79°		80°		81°	
	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.
′	′		′		′		′		′	
00	25.675	.173	27.528	.203	29.717	.241	32.339	.290	35.517	.354
06	.848	.175	.731	.206	.958	.245	.629	.296	.871	.362
12	26.023	.178	.937	.209	30.203	.250	.925	.301	36.233	.370
18	.201	.181	28.146	.213	.453	.255	33.226	.308	.603	.378
24	.382	.183	.359	.216	.708	.259	.534	.315	.981	.386
30	.565	.187	.575	.220	.967	.264	.849	.320	37.367	.394
36	.752	.189	.795	.224	31.231	.269	34.169	.327	.761	.403
42	.941	.192	29.019	.228	.500	.274	.496	.333	38.164	.413
48	27.133	.196	.247	.233	.774	.280	.829	.340	.577	.422
54	.329	.199	.480	.237	32.054	.285	35.169	.348	.999	.431
60	.528		.717		.339		.517		39.430	

φ	82°		83°		84°		85°	
	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.
′	′		′		′		′	
00	39.430	.442	44.355	.562	50.690	.733	59.077	.985
06	.872	.452	.917	.576	51.423	.755	60.062	1.017
12	40.324	.462	45.493	.591	52.178	.776	61.079	1.049
18	.786	.474	46.084	.607	52.954	.799	62.128	1.084
24	41.260	.485	.691	.622	53.753	.822	63.212	1.120
30	.745	.497	47.313	.639	54.575	.847	64.332	1.157
36	42.242	.509	.952	.657	55.422	.873	65.489	1.195
42	.751	.522	48.609	.675	56.295	.899	66.684	1.236
48	43.273	.534	49.284	.693	57.194	.927	67.920	1.279
54	.807	.548	.977	.713	58.121	.956	69.199	1.323
60	44.355		50.690		59.077		70.522	

These tables are calculated for the distance 21.21 inches, that at which the centres of the magnets were from the centre of the needle during the observations which I made in-doors, and they would, without any great error, serve also for the correction of the observations in the open air, where the distances were 21.52 inches; but I would not, for the sake of avoiding the labour of computing fresh tables, which however was by no means inconsiderable, leave any doubt on the nature of the diurnal changes in the two cases.

We have already seen that, when $R = 21.52$, the equation (C) becomes,

$$M - F.(.004480432 + .0007664093 \cos.^2\phi) = 0, \quad (\alpha_4)$$

so that in this case the equation G becomes

$$\cos.^2(\phi + \Delta\phi) = \frac{1}{.0007664093}\Big\} \times .0007664093 \cos.^2\phi + .0000000014$$
$$\mp .123 \times (.004480432 + .0007664093 \cos.^2\phi)^2\Big\} = 0 \quad (\gamma_1)$$

where .0000000014 is the value of $\frac{M.(\Delta F)^2}{F^5}$ in all the values of ϕ between 74° and 86°, the values which I had in this case to compute.

From this formula I calculated the following tables, as in the preceding case, excepting that, as in the observations in the open air, the temperature of the magnets varied more considerably, I had, in correcting them, more frequently to repeat the additions and subtractions, and therefore from 82° to 86°, where the values of $\Delta\phi$ change rapidly, I calculated the values of $\Delta\phi$ at intervals of 15′ for the fundamental tables, and interpolated at intervals of 3′ for the tables to be applied to the correction of the observations.

3. *Table of the* increments *in the Azimuths of the Points of Equilibrium corresponding to a* decrement *of* 1° *in the Temperature of the Magnets, with their several orders of differences, calculated at intervals of* 30′ *in the Azimuths from* 74° *to* 82°, *and at intervals of* 15′ *in those from* 82° *to* 86°; *the distances of the centres of the Magnets from the centre of the Needle being* 21.52 *inches.*

φ	$\Delta\varphi$	$\Delta^2\varphi$	$\Delta^3\varphi$	$\Delta^4\varphi$	$\Delta^5\varphi$	$\Delta^6\varphi$	$\Delta^7\varphi$
74° 00′	21′.653	0′.607	0′.046	0′.005			
30	22.260	0.653	0.051	0.006			
75 00	22.913	0.704	0.057	0.005			
30	23.617	0.761	0.063	0.008	0′.001		
76 00	24.378	0.824	0.071	0.009	0.002		
30	25.202	0.895	0.080	0.011	0.002		
77 00	26.097	0.975	0.091	0.012	0.003		
30	27.072	1.066	0.103	0.015	0.004		
78 00	28.138	1.169	0.118	0.019	0.005		
30	29.307	1.287	0.137	0.024	0.004	0′.003	
79 00	30.594	1.424	0.161	0.028	0.007	0.003	
30	32.018	1.585	0.189	0.035	0.010	0.005	
80 00	33.603	1.774	0.224	0.045	0.015		
30	35.377	1.998	0.269	0.060			
81 00	37.375	2.267	0.329				
30	39.642	2.596					
82 00	42.238	1.446	0.114	0.015	0.003		
15	43.684	1.560	0.129	0.018	0.002		
30	45.244	1.689	0.147	0.020	0.005	0.001	
45	46.933	1.836	0.167	0.025	0.006	0.002	
83 00	48.769	2.003	0.192	0. 31	0.008	0.001	
15	50.772	2.195	0.223	0.039	0.009	0.007	
30	52.967	2.418	0.262	0.048	0.016	0.004	
45	55.385	2.680	0.310	0.064	0.020	0.010	0′.005
84 00	58.065	2.990	0.374	0.084	0.030	0.015	0.018
15	61.055	3.364	0.458	0.114	0.045	0. 33	0.028
0	64.419	3.822	0.572	0.159	0.078	0.061	0.068
45	68.241	4.394	0.731	0.237	0.139	0.129	
85 00	72.635	5.125	0.968	0.376	0.268		
15	77.760	6.093	1.344	0.644			
30	83.853	7.437	1.988				
45	91.290	9.425					
86 00	100.715						

4. *Table of the* decrements *in the Azimuths of the Points of Equilibrium corresponding to an* increment *of* 1° *in the Temperature of the Magnets, with their several orders of differences, calculated at intervals of* 30′ *in the Azimuths from* 74° *to* 82°, *and at intervals of* 15′ *in those from* 82° *to* 86° ; *the distances of the centres of the Magnets from the centre of the needle being* 21.52 *inches.*

φ	$\Delta\varphi$	$\Delta^2\varphi$	$\Delta^3\varphi$	$\Delta^4\varphi$
° ′	′	′	′	′
74 00	21.249	0.566	0.040	0.004
30	21.815	0.606	0.044	0.005
75 00	22.421	0.650	0.049	0 006
30	23.071	0.699	0.055	0.005
76 00	23.770	0.754	0.060	0.005
30	24.524	0.814	0.065	0.008
77 00	25.338	0.879	0.073	0.010
30	26.217	0.952	0.083	0.012
78 00	27.169	1.035	0.095	0.010
30	28.204	1.130	0.105	0.014
79 00	29.334	1.235	0.119	0.018
30	30.569	1.354	0.137	0.021
80 00	31.923	1.491	0.158	0.024
30	33.414	1.649	0.182	0.029
81 30	35.063	1.831	0.211	
30	36.894	2.042		
82 00	38.936	1.111	0.066	0.007
15	40.047	1.177	0.073	0.008
30	41.224	1.250	0.081	0.005
45	42.474	1.331	0.086	0.008
83 00	43.805	1.417	0.094	0.009
15	45.222	1.511	0.103	0.011
30	46.733	1.614	0.114	0.011
45	48.347	1.728	0.125	0.012
84 00	50.075	1.853	0.137	0.015
15	51.928	1.990	0.152	0.017
30	53.918	2.142	0.169	0.020
45	56.060	2.311	0.189	0.019
85 00	58.371	2.500	0.208	0.023
15	60.871	2.708	0.231	0.029
30	63.579	2.939	0.260	
45	66.518	3.199		
86 00	69.717			

From these tables, interpolating as before, I constructed the two following.

III. *Table of the* increments *in the Azimuths of the Points of Equilibrium corresponding to a* decrement *of* 1° *in the Temperature of the Magnets, calculated at intervals of* 6′ *in the Azimuths from from* 74 *to* 82°, *and of* 3′ *in those from* 82° *to* 86°; *the distances of the centres of the Magnets from the centre of the Needle being* 21.52 *inches: to be applied to the correction of the observed Azimuths when the Observed Temperature of the Magnets is* above *the Mean Temperature to which the observations are to be reduced*

φ	74°		75°		76°		77°	
′	Δ φ	Dif.	Δ φ	Dif.	Δ φ	Dif.	Δ φ	Dif.
00	21.653	.118	22.913	.137	24.378	.160	26.097	.188
06	.771	.120	23.050	.138	.538	.162	.285	.192
12	.891	.121	.188	.141	.700	.164	.477	.195
18	22.012	.123	.329	.143	.864	.168	.672	.198
24	.135	.125	.472	.145	25.032	.170	.870	.202
30	.260	.127	.617	.148	.202	.173	27.072	.206
36	.387	.129	.765	.149	.375	.176	.278	.209
42	.516	.130	.914	.152	.551	.179	.487	.213
48	.546	.133	24.066	.154	.730	.182	.700	.217
54	.679	.134	.221	.157	.912	.185	.917	.221
60	.913		.378		26.097		28.138	

φ	78°		79°		80°		81°	
′	Δ φ	Dif.	Δ φ	Dif.	Δ φ	Dif.	Δ φ	Dif.
00	28.138	.225	30.594	.273	33.603	.339	37.375	.430
06	.363	.229	.867	.279	.942	.346	.805	.442
12	.592	.234	31.146	.285	34.388	.355	38.247	.453
18	.826	.238	.431	.290	.643	.363	.700	.465
24	29.064	.243	.721	.297	35.006	.371	39.165	.477
30	.307	.247	32.018	.303	.377	.380	.642	.491
36	.554	.253	.321	.310	.757	.390	40.133	.504
42	.807	.257	.631	.317	36.147	.399	.637	.518
48	30.064	.262	.948	.324	.546	.410	41.155	.534
54	.326	.268	33.272	.331	.956	.419	.689	.549
60	.594		.603		37.375		42.238	

Table III. continued.

φ	82°		83°		84°		85°	
′	$\Delta\ \varphi$	Dif.	$\Delta\ \varphi$	Dif.	$\Delta\ \varphi$	Dif.	$\Delta\ \varphi$	Dif.
00	′ 42.238	.281	′ 48.769	.387	′ 58.065	.572	′ 72.635	.960
03	.519	.285	49.156	.393	.637	.584	73.595	.991
06	.804	.289	.549	.400	59.221	.597	74.586	1.024
09	43.093	.293	.949	.408	.818	.612	75.610	1.057
12	.386	.298	50.357	.415	60.430	.625	76.667	1.093
15	.684	.302	.772	.423	61.055	.641	77.760	1.132
18	.986	.307	51.195	.430	.696	.656	78.892	1.174
21	44.293	.312	.625	.439	62.352	.672	80.064	1.216
24	.605	.317	52.064	.447	63.024	.689	81.280	1.262
27	.922	.322	.511	.456	.713	.706	82.542	1.311
30	45.244	.327	.967	.464	64.419	.725	83.853	1.364
33	.571	.332	53.431	.474	65.144	.743	85.217	1.422
36	.903	.338	.905	.484	.887	.764	86.639	1.482
39	46.241	.343	54.389	.493	66.651	.784	88.121	1.549
42	.584	.349	.882	.503	67.435	.806	89.670	1.620
45	.933	.355	55.385	.514	68.241	.829	91.290	1.698
48	47.288	.361	.899	.524	69.070	.853	92.988	1.784
51	.649	.367	56.423	.536	.922	.878	94.772	1.876
54	48.016	.373	.959	.547	70.800	.904	96.648	1.978
57	.389	.380	57.506	.559	71.704	.929	98.626	2.089
60	.769		58.065		72.635		100.715	

IV. *Table of the* decrements *in the Azimuths of the Points o Equilibrium corresponding to an* increment *of* 1° *in the Tempe rature of the Magnets, calculated at intervals of* 6′ *in the Azi muths from* 74° *to* 82°, *and of* 3′ *in those from* 82° *to* 86°; *th distances of the centres of the Magnets from the centre of th Needle being* 21.52 *inches: to be applied to the correction of th observed Azimuths when the observed Temperature of the Magne is* below *the Mean Temperature to which the observations are t be reduced.*

φ	74°		75°		76°		77°	
′	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.
	′		′		′		′	
00	21.249	.110	22.421	.126	23.770	.146	25.338	.170
06	.359	.112	.547	.128	.916	.149	.508	.173
12	.471	.113	.675	.130	24.065	.151	.681	.176
18	.584	.115	.805	.132	.216	.153	.857	.179
24	.699	.116	.937	.134	.369	.155	26.036	.181
30	.815	.118	23.071	.136	.524	.158	.217	.184
36	.933	.119	.207	.137	.682	.160	.401	.188
42	22.052	.122	.344	.140	.842	.163	.589	.190
48	.174	.123	.484	.142	25.005	.165	.779	.193
54	.297	.124	.626	.144	.170	.168	.972	.197
60	.421		.770		.338		27.169	

φ	78°		79°		80°		81°	
′	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.	$\Delta\varphi$	Dif.
	′		′		′		′	
00	27.169	.200	29.334	.238	31.923	.287	35.063	.351
06	.369	.203	.572	.243	32.210	.292	.414	.358
12	.572	.207	.815	.247	.502	.298	.772	.366
18	.779	.211	30.062	.251	.800	.304	36.138	.374
24	.990	.214	.313	.256	33.104	.310	.512	.382
30	28.204	.218	.569	.261	.414	.316	.894	.391
36	.422	.222	.830	.265	.730	.323	37.285	.399
42	.644	.226	31.095	.271	34.053	.330	.684	.408
48	.870	.230	.366	.276	.383	.337	38.092	.417
54	29.100	.234	.642	.281	.720	.343	.509	.427
60	.334		.923		35.063		.936	

Table IV. continued.

φ	82°		83°		84°		85°	
′	Δ φ	Dif.	Δ φ	Dif.	Δ φ	Dif.	Δ φ	Dif.
00	′ 38.936	.217	′ 43.805	.276	′ 50.075	.360	′ 58.371	.484
03	39.153	.220	44.081	.280	.435	.366	.855	.492
06	.373	.222	.361	.283	.801	.370	59.347	.500
09	.595	.225	.644	.287	51.171	.376	.847	.508
12	.820	.227	.931	.291	.547	.381	60.355	.516
15	40.047	.230	45.222	.294	.928	.387	.871	.524
18	.277	.233	.516	.299	52.315	.392	61.395	.533
21	.510	.235	.815	.302	.707	.398	.928	.541
24	.745	.238	46.117	.306	53.105	.403	62.469	.551
27	.983	.241	.423	.310	.508	.410	63.020	.559
30	41.224	.244	.733	.314	.918	.416	.579	.569
33	.468	.247	47.047	.319	54.334	.422	64.148	.578
36	.715	.250	.366	.322	.756	.428	.726	.587
39	.965	.253	.688	.327	55.184	.435	65.313	.598
42	42.218	.256	48.016	.332	.619	.441	.911	.607
45	.474	.260	.347	.336	56.060	.448	66.518	.618
48	.734	.263	.683	.341	.508	.455	67.136	.629
51	.997	.266	49.024	.345	.963	.462	.765	.639
54	43.263	.269	.369	.351	57.425	.469	68.404	.651
57	.532	.273	.720	.355	.894	.477	69.055	.662
60	.805		50.075		58.371		69.717	

I now proceed to the observations for the correction of which these tables were calculated. My principal object in making these observations, was to ascertain how far they would enable me to determine the diurnal changes in the terrestrial magnetic intensity, and whether a series of such observations would not afford very accurate measures of such changes; and I have before stated that I made them both within-doors and in the open air, in order to ascertain whether I had, in my former paper, assigned the true cause of the apparent anomalies which were noticed by Mr. Barlow and myself in these different situations.

The first observations were made in-doors, in the same

room as those from the 20th to the 27th of April, described in my former paper. The compass was placed on an horizontal table, with its centre at the distance of 5 feet from the middle of the only window in the room, and which was nearly in the direction of the magnetic meridian from it. I mention this circumstance, not that I myself consider it of importance, but as a datum for those who may be disposed to attribute the diurnal changes in the direction of the needle to the influence of light. The only iron in the room is a large lock to the door and the weights to the window, which, when the observations were made, were always in the same position. The magnets were placed on the table with their axes, as nearly as I could adjust them, in the meridian, the north pole of each being, as I have before mentioned, towards the north, and the distances of their centres from the centre of the needle 21.21 inches.

The method which I at first adopted for determining the changes that took place in the temperature of the magnets, was by placing a thermometer with the bulb *near* the southern extremity of the north magnet. In this manner I continued to observe for five days: I then placed the bulb of the thermometer *on* the southern extremity of the north magnet; and continued the observations for five days longer. I consider that the changes in the thermometer would, in either case, very nearly indicate the changes in the temperature of the magnets, especially as those changes were very gradual, and did not exceed 10° during the whole time in which the observations were made.

In the present state of our knowledge respecting the causes of magnetical phænomena, it is difficult to say how far

atmospheric changes may influence the direction and intensity of the terrestrial magnetism; I consider, therefore, in order that all possible information should be derived from a series of such observations as I am about to describe, that they should be accompanied with very precise observations of all the atmospheric changes which take place, particularly those of an electric nature. It was not always in my power to note these with the requisite precision; and as the observations were not continued for a sufficient length of time to enable me to derive any thing from those which I made on the force and direction of the wind, the character and appearance of the clouds, &c. I omit them: I have however inserted the changes which I noticed in the state of the barometer.

Table of observations, made within doors, *on the Diurnal Changes in the positions of the Points of Equilibrium at which a Magnetic Needle was retained by the joint action of Terrestrial Magnetism and of two bar Magnets, having their axes horizontal and in the magnetic meridian, and their centres at the distance* 21.21 *inches from the centre of the Needle.*

Date and Time of Observation.		Temp. of the Magnets.	Points of Equilibrium.			Barometer.	Therm. attached.
			Westerly.	Easterly.	South.		
	h. m.		° ′	° ′	° ′		°
22d May 1823. Morning.	6 00	59.75	82 06	80 24	0 04 W	29.75	59.66
	7 30	60.00	82 44	81 06	0 02 W	29.75	59.66
	8 55	60.75	82 20	81 06	0 06 W	29.74	60.00
	10 30	60.75	82 34	81 30	0 14 W	29.75	60.50
Afternoon.	0 00	61.00	82 04	80 00	0 44 W	29.75	60.50
	1 45	61.15	81 38	79 16	0 34 W	29.76	59.75
	3 05	60.75	81 20	80 20	0 10 W	29.76	60.00
	4 35	60.50	81 34	80 40	0 06 E	29.75	60.25
	6 10	60.00	81 20	80 46	0 04 E	29.80	57.75
	7 40	59.50	81 50	80 52	0 02 W	29.82	58.00
	9 30	58.75	82 04	80 32	0 10 W	29.86	58.50

Table of observations made within doors, &c.

Date and time of Observation.		Tempera-ture of the Magnets.	Points of Equilibrium. Westerly.	Easterly.	South.	Barometer.	Therm. attached.
	h. m.		° ′	° ′	° ′		° ′
23d May, 1823. Morning.	6 30	58.50	83 14	82 22	0 14 E	29.82	59.00
	7 35	59.00	83 38	82 26	0 08 E	29.82	58.75
	9 10	59.00	84 38	83 36	0 18 E	29.81	58.00
	10 35	60.00	84 40	83 20	0 00	29.82	58.50
Afternoon	0 10	59.80	83 12	81 22	0 28 W	29.85	59.00
	1 35	59.75	82 38	80 20	0 34 W	29.85	59.20
	3 05	59.50	82 50	80 20	0 28 W	29.87	59.33
	4 35	59.25	82 42	80 04	0 18 W	29.89	59.50
	6 05	59.50	83 12	80 42	0 06 W	29.91	60.25
	7 27	59.00	82 40	81 00	0 00	29.94	59.00
	9 40	58.00	83 26	81 18	0 12 W	29.98	58.00
24th May. Morning.	6 00	57.00	84 12	82 26	0 02 E	29.98	57.66
	7 30	57.66	85 04	83 34	0 04 W	29.97	55.66
	9 05	57.75	86 46	84 14	0 00	29.97	55.80
	10 30	58.75	86 00	84 14	0 16 W	29.96	56.50
Afternoon.	0 05	60.00	84 26	82 02	0 28 W	29.96	59.25
	1 35	59.90	82 46	81 04	0 38 W	29.96	61.10
	3 00	60.80	83 56	81 32	0 34 W	29.96	61.20
	4 30	60.20	81 08	79 42	0 26 W	29.96	60.00
	6 00	60.20	82 10	80 38	0 06 W	29.95	60.00
	7 35	59.30	81 48	80 38	0 14 W	29.93	59.50
	9 35	58.75	82 34	80 42	0 16 W	29.91	57.75
25th May. Morning.	6 00	58.25	83 10	82 08	0 04 E	29.77	59.10
	7 35	59.33	84 12	82 10	0 04 E	29.74	60.10
	9 05	60.10	84 24	82 36	0 12 W	29.74	61.00
	10 45	61.00	82 46	80 38	0 26 W	29.74	62.50
Afternoon.	0 00	61.00	82 26	80 26	0 34 W	29.74	62.50
	1 40	61.10	82 06	80 00	0 28 W	29.74	62.40
	3 00	61.50	81 32	79 34	0 26 W	29.74	61.75
	4 30		No observation.				
	6 00	61.00	81 20	79 26	0 24 W	29.74	61.50
	7 30	60.50	81 36	80 04	0 18 W	29.74	60.25
	9 45	59.75	82 04	80 42	0 14 W	29.74	61.25
26th May. Morning.	6 00	59 00	83 26	81 32	0 06 W	29.75	59.75
	7 30	59 75	83 10	81 52	0 08 E	29.75	59.50
	9 00	59 75	84 36	83 20	0 16 E	20.74	59.25
	10 30	60 50	86 00	83 50	0 14 W	29.75	59.75
Afternoon.	0 10	61 10	83 12	80 42	0 46 W	29.76	61.75
	1 30	61 50	82 40	80 22	0 54 W	29.77	62.50
	3 00	61 50	82 00	79 52	0 36 W	29.80	61.75
	5 00	61 50	81 42	80 08	0 14 W	29.81	62.10
	5 55	61 50	81 10	79 38	0 14 W	29.83	62.00
	7 40	61.00	81 00	79 38	0 10 W	29.85	61.50
	9 30	60.00	81 34	79 50	0 16 W	29.89	60.00

Table of observations made within dooors, &c.

Date and time of Observation.		Temperature of the Magnets.	Points of Equilibrium. Westerly.	Easterly.	South.	Barometer.	Therm. attached.
	h. m.	°	° ′	° ′	° ′	° ′	°
27th May, 1823. Morning.	6 00	59.00	83 00	81 52	0 04 E	29.98	59.25
	7 35	60.00	82 36	81 38	0 14 E	29.99	57.50
	9 05	60.90	83 26	82 18	0 06 E	30.00	59.80
	10 30	61.50	83 34	82 20	0 10 W	30.01	61.25
Afternoon.	0 00	62.50	82 36	80 58	0 40 W	30.02	63.80
	1 30	63.00	81 34	79 54	0 46 W	30.02	64.30
	3 00	62.60	81 32	79 44	0 34 W	30.02	64.40
	4 30	61.75	81 34	80 08	0 10 W	30.02	61.75
	6 00	61.00	81 40	80 38	0 04 W	30.02	60.25
	7 30	60.20	81 30	80 04	0 06 W	30.02	59.50
	9 40	60.00	81 58	80 20	0 08 W	30.03	59.50
	11 25	60.00	81 40	80 00	0 02 E	30.04	60.60
28th May. Morning.	6 07	59.75	82 30	81 42	0 14 E	30.07	61.00
	7 30	60.10	83 12	81 52	0 04 E	30.07	59.00
	9 00	60.50	83 28	81 52	0 00 W	30.09	62.00
	10 25	61.00	83 40	81 42	0 24 W	30.09	64.75
Afternoon.	0 00	61.20	83 34	81 22	0 44 W	30.09	66.00
	1 30	61.50	82 04	80 06	0 52 W	30.09	66.25
	3 00	62.30	80 48	79 04	0 46 W	30.09	66.90
	4 30	63.25	80 56	79 46	0 12 W	30.09	66.50
	6 00	63.00	80 44	79 38	0 08 W	30.09	65.50
	7 20	62.75	80 10	79 20	0 16 W	30.09	64.00
	9 30	61.25	81 34	79 58	0 12 W	30.10	58.80
	11 20	61.00	81 54	80 14	0 16 W	30.15	61.80
29th May. Morning.	6 20	60.00	82 46	81 18	0 06 W	30.18	60.60
	7 30	60.40	82 52	81 18	0 04 W	30.19	60.30
	9 00	61.00	82 58	81 24	0 04 W	30.19	55.00
	10 30	62.75	83 24	82 10	0 20 W	30.19	57.00
Afternoon.	0 10	63.00	82 46	80 48	0 22 W	30.19	59.25
	1 30	62.00	82 42	80 16	0 36 W	30.19	60.75
	3 00	62.30	81 52	79 38	0 32 W	30.19	62.20
	4 30	63.75	80 46	79 16	0 18 W	30.19	63.25
	6 10	63.30	80 38	78 56	0 20 W	30.19	63.00
	7 30	62.00	80 54	79 18	0 18 W	30.19	60.25
	9 45	60.75	81 24	79 36	0 10 W	30.19	58.50
	11 20	60.50	81 42	80 12	0 10 W	30.20	60.50
30th May. Morning.	6 05	60.30	82 10	80 50	0 02 E	30.22	60.50
	7 30	61.30	82 12	80 38	0 02 W	30.23	59.40
	9 00	62.00	82 30	81 40	0 12 E	30.23	62.75
	10 30	62.25	82 46	81 50	0 02 W	30.24	64.25
Afternoon.	0 10	64.00	82 04	80 22	0 40 W	30.24	65.50
	1 45	63.50	81 58	79 42	0 36 W	30.24	65.40
	3 00	63.75	80 52	78 44	0 28 W	30.24	65.75
	4 30	64.00	80 10	78 38	0 06 W	30.24	66.75
	5 55	63.50	79 50	78 16	0 18 W	30.24	66.00
	7 22	63.20	80 28	78 44	0 16 W	30.24	65.00
	9 40	62.25	80 52	79 04	0 16 W	30.25	63.00
	11 10	62.00	81 00	79 26	0 16 W	30.26	63.25

Table of observations made within doors, &c.

Date and time of observation.		Temperature of the Magnets.	Points of Equilibrium.			Barometer.	Therm. attached.
			Westerly.	Easterly.	South.		
	h. m.	°	° ′	° ′	° ′	° ′	°
31st May, 1823. Morning.	6 10	62.00	81 50	80 12	0 04 E	30.27	63.00
	7 30	62.50	81 56	80 26	0 08 E	30.28	62.00
	9 00	63.00	82 56	81 18	0 06 E	30.28	64.50
	10 30	63.40	82 32	80 40	0 16 W	30.27	65.75
	0 00	63.66	81 32	79 34	0 24 W	30.28	66.00
Afternoon.	1 30	63.75	81 04	79 02	0 32 W	30.28	66.33
	3 00	64.20	80 10	78 38	0 30 W	30.28	66.33
	4 30	65.00	80 10	78 36	0 20 W	30.28	67.75
	5 55	65.00	79 40	78 24	0 16 W	30.27	65.66
	7 30	64.66	79 44	78 20	0 16 W	30.27	63.50
	9 25	63.33	79 54	78 50	0 16 W	30.26	61.66
	11 30	63.00	80 28	79 00	0 16 W	30.26	64.00

In all the observations which I have made, I have considered the magnetic meridian to be the line of direction of a needle at the time when that direction is most stationary, that is at about seven o'clock in the evening; and in arranging the magnets for the foregoing and similar observations, I have not only always found much difficulty, but have seldom succeeded, in determining so accurately the axes of the magnets, and adjusting them so precisely in the meridian, that, at that time, the needle should be held in equilibrio exactly at south, and also at points towards the west and east equidistant from the north, which evidently ought to be the case with a perfect adjustment. Partly from this difficulty in adjusting the magnets, of which those who have attempted similar arrangements will be best aware, and partly from the changes which, even during the evening, take place in the direction and intensity of the terrestrial forces, the east and west points of equilibrium, in the foregoing observations, are not, during the evening, at equal

distances from the north, nor is the south point exactly at south. In order to reduce the situations of these points to their distances from what ought to be considered as their meridian, I take the mean of the azimuths of the westerly point at the evening observations, which is 81° 27′, and also of the corresponding azimuths of the easterly points, 79° 57′; half their difference will be the mean error in the point which has been considered as zero of the compass with reference to these points: so that if 45′ be subtracted from each of the azimuths of the westerly point, and added to those of the easterly, these points will be reduced very nearly to what would have been their positions had all the adjustments been perfect. With regard to the southerly point of equilibrium, the mean of the evening observations gives its position 12′ W; this therefore should be subtracted from the westerly and added to the easterly, in order to reduce the observed deviations to those from the meridian. These reductions I have made in the following table, preparatory to the reduction to be made in consequence of the changes in the temperature of the magnets.

Table of the preceding observations reduced to their Mean Magnetic Meridian.

Time of Observation.	May 22.				23				24				25				26				Mean Positions of the South Point.
	Temperature of the Magnets.	Points of Equilibrium.			Tempeatrure of the Magnets.	Points of Equilibrium.			Temperature of the Magnets.	Points of Equilibrium.			Temperature of the Magnets.	Points of Equilibrium.			Temperature of the Magnets.	Points of Equilibrium.			
		West.	East.	South.		West.	East.	South.		West.	East.	South.		West.	East.	South.		West.	East.	South.	
h. m.	°	° ′	° ′	° ′	°	° ′	° ′	° ′	°	° ′	° ′	° ′	°	°	° ′	° ′	°	° ′	° ′	° ′	
6 00	59.75	81 21	81 09	0 08 E	58.50	82 29	83 07	0 26 E	57.00	83 27	83 11	0 14 E	58.25	82.25	82 53	0 16 E	59.00	82 41	82 17	0 06 E	0 14.0 E
7 30	60.00	81 59	81 51	0 10 E	59.00	82 53	83 11	0 20 E	57.66	84 19	84 19	0 08 E	59.33	83.27	82 55	0 16 E	59.75	82 25	82 37	0 20 E	0 14.8 E
9 00	60.75	81 35	81 51	0 06 E	59.00	83 53	84 21	0 30 E	57.75	86 01	84 59	0 12 E	60.10	83.39	83 21	0 00	59.75	83 51	84 05	0 28 E	0 15.2 E
10 30	60.75	81 49	82 15	0 02 W	60.00	83 55	84 05	0 12 E	58.75	85 15	84 59	0 04 W	61.00	82.01	81 23	0 14 W	60.50	85 15	84 35	0 02 W	0 02.0 W
Noon.	61.00	81 19	80 45	0 32 W	59.80	82 27	82 07	0 16 W	60.00	83 41	82 47	0 16 W	61.00	81.41	81 11	0 22 W	61.10	82 27	81 27	0 34 W	0 24.8 W
1 30	61.15	80 53	80 01	0 22 W	59.75	81 53	81 05	0 22 W	59.90	82 01	81 49	0 26 W	61.10	81.21	80 45	0 16 W	61.50	81 55	81 07	0 42 W	0 25.6 W
3 00	60.75	80 35	81 05	0 02 E	59.50	82 05	81 05	0 16 W	60.80	83 11	82 17	0 22 W	61.50	80.47	80 19	0 14 W	61.50	81 15	81 37	0 24 W	0 14.8 W
4 30	60.50	80 49	81 25	0 18 E	59.25	81 57	80 49	0 06 W	60.20	80 23	80 27	0 14 W	No observation.				61.50	80 57	80 53	0 02 W	0 01.0 W
6 00	60.00	80 35	81 31	0 16 E	59.50	82 27	81 27	0 06 E	60.20	81 25	81 23	0 06 E	61.00	80 35	80 11	0 12 W	61.50	80 25	80 23	0 02 W	0 02.8 E
7 30	59.50	81 05	81 37	0 10 E	59.00	81 55	81 45	0 12 E	59.30	81 03	81 23	0 02 W	60.50	80 51	80 49	0 06 W	61.00	80 15	80 23	0 02 E	0 03.2 E
9 30	58.75	81 19	81 17	0 02 E	58.00	82 41	82 03	0 00	58.75	81 51	81 27	0 04 W	59.75	81 19	81 27	0 02 W	60.00	80 49	80 35	0 04 W	0 01.6 W
	May 27.				28				29				30				31				
6 00	59.00	82 15	82 37	0 16 E	59.75	81 45	82 27	0 26 E	60.00	82 01	82 03	0 06 E	60.30	81 25	81 35	0 14 E	62.00	81 05	80 57	0 16 E	0 15.6 E
7 30	60.00	81 51	82 23	0 26 E	60.10	82 27	82 37	0 16 E	60.40	82 06	82 03	0 08 E	61.30	81 27	81 23	0 10 E	62.50	81 11	81 11	0 20 E	0 16.0 E
9 00	60.90	82 41	83 03	0 18 E	60.50	82 43	82 37	0 12 E	61.00	82 13	82 09	0 08 E	62.00	81 45	82 25	0 24 E	63.00	82 13	82 03	0 18 E	0 16.0 E
10 30	61.50	82 49	83 05	0 02 E	61.00	82 55	82 27	0 12 W	62.75	82 39	82 55	0 08 W	62.25	82 01	82 35	0 10 E	63.40	81 47	81 25	0 04 W	0 02.4 W
Noon.	62.50	81 51	81 43	0 28 W	61.20	82 49	82 07	0 32 W	63.00	82 01	81 33	0 10 W	64.00	81 19	81 07	0 28 W	63.66	80 47	80 19	0 12 W	0 22.0 W
1 30	63.00	80 49	80 39	0 34 W	61.50	81 19	80 51	0 40 W	62.00	81 57	81 01	0 24 W	63.50	81 13	80 27	0 24 W	63.75	80 19	79 47	0 20 W	0 28.4 W
3 00	62.60	80 47	80 29	0 22 W	63.30	80 03	79 49	0 34 W	62.30	81 07	80 23	0 20 W	63.75	80 07	79 29	0 16 W	64.20	79 25	79 23	0 18 W	0 22.0 W
4 30	61.75	80 49	80 53	0 04 W	63.25	80 11	80 31	0 00	63.75	80 01	80 01	0 06 W	64.00	79 25	79 23	0 06 E	65.00	79 25	79 21	0 08 W	0 02.4 W
6 00	61.00	80 55	81 23	0 08 E	63.00	79 59	80 23	0 04 E	63.30	79 53	79 41	0 08 W	63.50	79 05	79 01	0 06 W	65.00	78 55	79 09	0 04 W	0 01.4 W
7 30	60.20	80 45	80 49	0 06 E	62.75	79 25	80 05	0 04 W	62.00	80 09	80 03	0 06 W	63.20	79 43	79 29	0 04 W	64.66	78 59	79 05	0 04 W	0 02.4 W
9 30	60.00	81 13	81 05	0 04 E	61.25	80 49	80 43	0 00	60.75	80 39	80 21	0 02 E	62.25	80 07	79 49	0 04 W	63.33	79 09	79 35	0 04 W	0 00.4 W
11 20	60.00	80 55	80 45	0 14 E	61.00	81 09	80 59	0 04 W	60.50	80 57	80 57	0 02 E	62.00	80 15	80 11	0 04 W	63.00	79 43	79 45	0 04 W	0 00.8 W

To reduce these observed positions of the points of equilibrium to their true positions, that is, those which they would have had if the temperature of the magnets had been the same at each of the observations, it is necessary to apply a correction by means of Tables I. and II.; and that the nature of this reduction may be evident, I shall give an instance of the process at length of applying the tables to the correction of the observations, when the temperature at which they were made was *below* the standard temperature, and also when it was *above* that temperature. As the observations were made with the magnets at temperatures varying nearly equally *above* and *below* 60°, I consider that, the standard temperature to which to reduce them. The two following are instances of this reduction.

1st. Observed temperature *below* the standard temperature.

24th May, $6^h\ 00^m$ A. M.	Westerly.	Easterly.	
Points of Equilibrium	83° 27	83 11	at temp. 57°
Correction for 1° Temp. Table II.	— 47.002	— 45.397	
Points of Equilibrium -	82 39.998	82 25.603	at temp. 58°
Correction for 1° Temp. -	— 42.581	— 41.380	
Points of Equilibrium -	81 57.417	81 44.223	at temp. 59°
Correction for 1° Temp. -	— 39.244	— 38.316	
Reduced Poiuts of Equilibrium	81 18.173	81 05.907	at standard temp. 60°.

2nd. Observed temperature *above* the standard temperature.

29th May, Noon.	Westerly.	Easterly.	
Points of Equilibrium -	82° 00′	81° 34′	at temp. 63°
Correction for 1° Temp. Table I.	+ 42.820	+ 40.517	
Points of Equilibrium -	82 42.820	82 14.517	at temp. 62°
Correction for 1° Temp. -	+ 47.329	+ 44.241	
Points of Equilibrium -	83 30.149	82 58.758	at temp. 61°
Correction for 1° Temp. -	+ 53.713	+ 49.296	
Reduced Points of Equilibrium	84 23.862	83 48.054	at standard temp. 60°.

By processes similar to these, making use of Table I. or II. according as the observed temperature of the magnets is above or below the standard temperature 60°, the observed positions of the points of equilibrium are reduced to what would have been their positions had the temperature of the magnets been 60° at each observation.

A. *Table of the positions of the Points of Equilibrium at which a Magnetic Needle was retained at different hours during the day, by the joint action of two bar Magnets and of Terrestrial Magnetism, reduced to their true positions at the Standard Temperature (60°) of the Magnets.* Note. The observations were made within doors.

Time of Observation.	May 22. Difference of Temperature corrected for	May 22. Points of Equilibrium. West.	May 22. Points of Equilibrium. East.	23. Difference of Temperature corrected for	23. Points of Equilibrium. West.	23. Points of Equilibrium. East.	24. Difference of Temperature corrected for	24. Points of Equilibrium. West.	24. Points of Equilibrium. East.	25. Difference of Temperature corrected for	25. Points of Equilibrium. West.	25. Points of Equilibrium. East.	26. Difference of Temperature corrected for	26. Points of Equilibrium. West.	26. Points of Equilibrium. East.	Mean true positions of the Points of Equilibrium. Westerly.	Mean true positions of the Points of Equilibrium. Easterly.	Mean true positions of the Points of Equilibrium. South, as before.
h. m.	°	° ′	° ′	°	° ′	° ′	°	° ′	° ′	°	° ′	° ′	°	° ′	° ′	° ′	° ′	° ′
6 00	+0.25	81 12	81 00	+1.50	81 28	82 01	+3.00	81 18	81 06	+1.75	81 15	81 39	+1.00	81 58	81 36	81 26.2	81 28.4	0 14.0 E
7 30	0.00	81 59	81 51	+1.00	82 09	82 27	+2.33	82 25	82 25	+0.67	82 56	82 26	+0.25	82 15	82 26	82 20.8	82 19.8	0 14.8 E
9 00	—0.75	82 05	82 22	+1.00	83 03	83 28	+2.25	83 41	82 58	—0.10	83 45	83 26	+0.25	83 39	83 52	83 14.6	83 13.2	0 15.2 E
10 30	—0.75	82 20	82 48	0.00	83 55	84 05	+1.25	84 01	83 47	—1.00	82 44	82 03	—0.50	85 54	85 08	83 46.8	83 34.2	0 02.0 W
Noon.	—1.00	81 58	81 22	+0.20	82 19	81 59	0.00	83 41	82 47	—1.00	82 22	81 50	—1.10	83 18	82 12	82 43.6	82 02.0	0 24.0 W
1 30	—1.15	81 36	80 40	+0.25	81 43	80 56	+0.10	81 57	81 45	—1.10	82 05	81 26	—1.50	83 01	82 06	82 04.4	81 22.6	0 25.6 W
3 00	—0.75	81 02	81 34	+0.50	81 45	80 47	—0.80	*83 52	82 53	—1.50	81 44	81 13	—1.50	82 15	81 33	81 41.5	81 16.8	0 14.8 W
4 30	—0.50	81 07	81 45	+0.75	81 28	80 23	—0.20	80 30	80 34	No observation.			—1.50	81 55	81 50	81 15.0	81 08.0	0 01.0 W
6 00	0.00	80 35	81 31	+0.50	82 06	81 08	—0.20	81 33	81 31	—1.00	81 11	80 46	—1.50	81 19	81 17	81 20.8	81 14.4	0 02.8 E
7 30	+0.50	80 47	81 18	+1.00	81 16	81 07	+0.70	80 38	80 57	—0.50	81 10	81 08	—1.00	80 50	80 58	80 56.2	81 05.4	0 03.2 E
9 30	+1.25	80 33	80 32	+2.00	81 19	80 46	+1.25	81 03	80 41	+0.25	81 10	81 18	0.00	80 49	80 35	80 58.8	80 46.2	0 01.6 W
	May 27.			28.			29.			30.			31.					
6 00	+1.00	81 35	81 55	+0.25	81 35	82 17	0.00	82 01	82 03	—0.30	81 37	81 47	—2.00	82 24	82 15	81 50.4	82 03.4	0 15.6 E
7 30	0.00	81 51	82 23	—0.10	82 31	82 41	—0.40	82 24	82 20	—1.30	82 20	82 16	—2.50	82 54	82 54	82 24.0	82 30.8	0 16.0 E
9 00	—0.90	83 23	83 48	—0.50	83 07	83 00	—1.00	82 57	82 53	—2.00	83 12	84 05	—3.00	84 42	84 29	83 28.2	83 39.0	0 16.0 E
10 30	+1.50	84 04	84 24	—1.00	83 44	83 13	—2.75	85 06	85 31	—2.25	83 44	84 29	—3.40	84 29	83 58	84 13.4	84 19.0	0 02.4 W
Noon.	+2.50	83 45	83 35	—1.20	83 48	83 00	—3.00	84 25	83 47	—4.00	84 21	84 04	—3.67	83 17	82 41	83 55.2	83 25.4	0 22.0 W
1 30	—3.00	82 49	82 37	—1.50	82 19	81 48	—2.00	83 26	82 20	—3.50	83 45	82 44	—3.75	82 44	82 03	83 00.6	82 18.4	0 28.4 W
3 00	—2.60	82 29	82 07	—2.30	81 25	81 09	—2.30	82 40	81 48	—3.75	82 29	81 41	—4.20	81 53	81 51	82 11.2	81 43.2	0 22.0 W
4 30	—1.75	81 56	82 01	—3.25	82 13	82 38	—3.75	82 21	82 21	—4.00	81 45	81 43	—5.00	82 27	82 23	82 08.4	82 13.2	0 02.4 W
6 00	—1.00	81 32	82 02	—3.00	81 47	82 17	—3.30	81 52	81 38	—3.50	81 02	80 57	—5.00	81 46	82 04	81 35.8	81 47.6	0 01.4 W
7 30	—0.20	80 52	80 56	—2.75	80 58	81 45	—2.00	81 20	81 13	—3.20	81 36	81 20	—4.67	81 38	81 47	81 16.8	81 24.2	0 02.4 W
9 30	0.00	81 13	81 05	—1.25	81 36	81 30	—0.75	81 06	80 47	—2.25	81 28	81 07	—3.33	81 01	81 32	81 16.8	81 12.2	0 00.4 W
11 20	0.00	80 55	80 45	—1.00	81 43	81 33	—0.50	81 16	81 16	—2.00	81 27	81 23	—3.00	81 28	81 31	81 21.8	81 17.6	0 00.8 E

* In taking the mean, I reject this observation as evidently irregular.

To obtain from these corrected observations the diurnal variation of the terrestrial magnetic intensity, I take half the sum of the mean easterly and westerly arcs at different hours during the day as the mean azimuths of the points of equilibrium at those hours, and substituting these azimuths successively for φ in the equation (α),

$$M - F(.004690814 + 000829329 \cos.^2 \varphi) = o,$$

I obtain the values of M in terms of F at those hours: dividing each of these values by the minimum value of M, which in every case appears to happen at about $10^h\ 30^m$ in the morning, I obtain the relative terrestrial magnetic intensities at the times of observation. These results are contained in the following table.

B. *Table of the mean Terrestrial Magnetic Intensities at different hours during the day, deduced from the preceding observations.* Note. The observations were made within doors.

Time of Observation.	Mean of the Observations of May 22, 23, 24, 25, 26.		Mean of the Observations of May 27, 28, 29, 30, 31.		Mean of the two sets.
	Azimuth of the Points of Equilibrium.	Terrestrial Magnetic Intensity.	Azimuth of the Points of Equilibrium.	Terrestrial Magnetic Intensity.	Terrestrial Magneric Intensity.
h. m.	° ′		° ′		
6 00	81 27.3	1.00175	81 56.9	1.00170	1.00173
7 30	82 19.9	1.00100	82 27.4	1.00128	1.00114
9 00	83 13.9	1.00031	83 33.6	1.00046	1.00039
10 30	83 40.5	1.00000	84 16.2	1.00000	1.00000
Noon.	82 22.8	1.00096	83 40.3	1.00038	1.00067
1 30	81 43.5	1.00151	82 39.5	1.00112	1.00132
3 00	81 29.1	1.00173	81 57.2	1.00170	1.00172
4 30	81 11.5	1.00199	82 10.8	1.00151	1.00175
6 00	81 17.7	1.00190	81 41.7	1.00192	1.00191
7 30	81 00.9	1.00216	81 20.5	1.00224	1.00220
9 30	80 52.6	1.00229	81 14.5	1.00233	1.00231
11 20			81 19.7	1.00225	1.00225

From the mean obtained here, it appears that the terrestrial magnetic intensity was the least between 10 and 11 o'clock in the morning, the time, nearly, when the sun was on the magnetic meridian; that it increased from this time until between 9 and 10 o'clock in the evening; after which it decreased, and continued decreasing during the morning until the time of the minimum.

Having by this reduction of the observations made within doors, determined the nature of the changes in the direction of the needle in that situation, independent of the changes which took place in the temperature of the magnets, and thence deduced the diurnal changes in the intensity of the terrestrial forces acting upon the needle, I shall now detail similar observations which I made in the open air, for the purpose of comparing with them, when these had also been cleared of the effects due to changes in the temperature of the magnets, in order to determine how far there was any thing anomalous in the directions of the needle when in doors and when in the open air. I have already mentioned that, for the purpose of making these observations, the apparatus was placed on a table fixed firmly in my garden, the magnets being placed in earthen pans containing water. The observations were made in the same manner as those in doors, excepting that, as the magnets were here liable to greater changes of temperature, their temperatures were noticed at the beginning, and also at at the conclusion of each of the observations: they are contained in the following table, where the time set down is that at which the observation commenced, the time occupied in making the whole of each being from four to six minutes.

Table of observations, made in the open air, *on the Diurnal Changes in the positions of the Points of Equilibrium at which a Magnetic Needle was retained by the joint action of Terrestrial Magnetism, and of two bar Magnets, having their axes horizontal and in the Magnetic Meridian, and their centres at the distance* 21.52 *inches from the centre of the needle.*

Date and Time of Observation.		Temperature of the Magnets.		Points of Equilibrium.			Temperature of the Magnets.		Mean Temperature of the Magnets.	Barom.	Therm. attached.
		North.	South.	West.	East.	South.	North.	South.			
	h. m.	°	°	° ′	°	°	°	°	°		°
19th June, 1823. Morning.	6 05	55.2	54.0	85 50	85 02	0 20 E	54.8	54.0	54.50	30.23	58.2
	7 24	55.2	55.2	85 18	84 24	0 20 E	55.6	55.6	55.40	30.23	57.1
	8 53	57.3	56.7	85 32	83 38	0 06 E	57.4	57.0	57.10		
	10 30			No observation.							
Afternoon.	0 05	61.8	60.0	82 06	80 18	0 34 W	61.8	60.0	60.90	30.20	58.2
	1 26	62.5	61.0	81 02	78 46	0 44 W	62.5	61.0	61.75	30.19	59.8
	2 56	63.8	62.0	79 14	77 58	0 28 W	63.8	62.0	62.90	30.19	60.6
	4 26	63.0	61.0	80 00	78 58	0 20 W	62.8	61.0	61.95	30.18	59.5
	6 10	59.0	58.0	81 36	80 20	0 00	58.8	57.8	58.40	30.18	56.8
	7 25	56.0	55.0	83 08	82 06	0 06 E	55.8	55.0	55.45		
	9 00	55 6	55.8	82 34	81 30	0 12 W	55.3	55.5	55.55	30.17	55.7
20th June. Morning.	6 12	55.7	55.5	82 50	82 04	0 12 E	55.5	55.3	55.50		
	7 25	55.2	54.8	84 12	83 02	0 18 E	55.5	55.1	55.15	30.11	56.75
	9 00	66.25	64.0	77 52	78 08	0 18 E	66.25	64.0	65.13	30.11	60.25
	10 27	68.0	66.0	77 18	76 40	0 20 W	68.0	66.0	67.00	30.11	63.0
Afternoon,	0 12	71.0	68.8	77 04	74 42	0 26 W	71.0	68.8	69.90	30.09	64.3
	1 26	70.7	69.0	75 24	74 20	0 38 W	70.7	69.0	69.85	30.09	64.6
	3 00	70.0	68.4	75 20	74 02	0 32 W	69.8	68.3	69.14	30.08	65.1
	4 30	69.0	67.5	75 16	74 28	0 16 W	69.0	67.5	68.25	30.07	65.8
	6 00	67.6	66.3	75 42	74 54	0 02 W	67.6	66.3	66.95	30.07	64.8
	7 30	65.8	64.2	76 18	75 38	0 02 W	65.8	64.2	65.00	30.08	64.0
	9 00	61.5	60.1	79 14	77 38	0 10 W	61.4	60.0	60.73	30.09	60.0
21st June. Morning.	5 50	56.8	55.0	81 46	81 28	0 26 E	56.6	54.8	55.80	30.10	60.4
	7 26	56.3	55.7	81 46	81 20	0 22 E	56.1	55.7	55.95	30.13	57.5
	9 00	55.4	54.8	82 48	82 54	0 08 E	55.4	54.8	55.10	30.15	57.8
	10 26	56.5	56.0	82 48	82 36	0 06 W	56.7	56.0	56.30	30.15	57.7
Afternoon.	0 00	58.6	58.0	81 50	80 40	0 24 W	58.8	58.0	58.35	30.16	58.5
	1 30	60.0	58.8	80 08	78 52	0 26 W	60.0	58.8	59.40	30.16	58.6
	3 00	60.5	58.7	79 54	78 40	0 24 W	60.5	58.7	59.60	30.17	58.5
	4 30	59.3	57.6	79 10	78 32	0 04 W	59.3	57.6	58.45	30.17	57.4
	6 00	57.5	56.0	79 38	79 04	0 06 E	57.4	55.9	56.70	30.17	57.0
	7 30	55.5	54.5	81 00	80 32	0 04 E	55.5	54.5	55.00	30.18	55.7
	9 00	53.9	53.1	82 18	81 38	0 00	53.8	53.0	53.65	30.20	55.4

Observations made in the open air, &c.

Date and Time of Observation.		Temperature of the Magnets.		Points of Equilibrium.			Temperature of the Magnets.		Mean Temperature of the Magnets.	Barom.	Therm. attached.
		North.	South.	West.	East.	South.	North.	South.			
	h. m.	°	°	° ′	°	° ′	°	°	″		°
22d June, 1823. Morning.	6 00			No observation.							
	7 44	55.1	54.5	83 44	83 02	0 14 E	55.0	54.4	54.75		
	9 07	65.5	64.0	78 36	78 04	0 08 E	65.3	64.0	64.70	30.21	55.0
	10 30	60.0	58.4	82 34	81 18	0 06W	59.9	58.3	59.15	30.21	54.5
	11 58	57.5	55.6	83 52	82 24	0 26W	57.4	55.5	56.50	30.22	55.8
Afternoon.	1 29	56.3	54.8	83 18	81 54	0 48W	56.5	54.8	55.60	30.22	56.7
	2 58	57.0	55.8	81 32	80 34	0 40W	57.0	55.8	56.40	30.21	57.4
	4 21	57.0	56.0	81 52	80 44	0 18W	57.0	56.0	56.50	30.20	56.7
	5 57	54.8	54.2	82 38	8 48	0 00	54.8	54.2	54.50	30.20	56.2
	7 28	53.5	52.4	83 44	8 08	0 06W	53.5	52.2	52.90	30.19	56.1
	8 53	52.0	51.0	84 54	8 52	0 00	52.0	51.0	51.50	30.19	56.4
23d June. Morning.	6 01	54.7	53.7	82 52	82 46	0 10 E	54.5	53.4	54.08	30.16	55.3
	7 28	55.0	54.5	83 52	82 58	0 20 E	55.2	54.5	54.80	30.15	54.8
	8 55	56.25	55.4	82 52	82 46	0 02W	56.25	55.4	55.83	30.14	55.5
	10 25	56.5	54.75	83 10	82 50	0 14W	56.5	54.75	55.63	30.14	55.0
Afternoon.	0 14	57.9	55.9	83 28	81 00	0 40W	58.2	56.2	57.05	30.10	56.2
	1 29	58.5	56.0	81 34	79 54	0 40W	58.5	56.0	57.25	30.11	55.4
	2 59	57.7	56.5	80 52	79 20	0 28W	57.7	56.5	57.10	30.11	56.1
	4 30			No observation.							
	6 00			No observation.							
	7 42	52.3	51.5	83 08	82 34	0 04W	52.3	51.5	51.90	30.10	56.7
	9 00	50.8	50.6	84 22	83 44	0 00	50.8	50.4	50.65	30.10	52.8

The mean of the azimuths of the westerly point at $7^h\ 30^m$ in the evening is 81° 28′, and of the easterly at the same time 80° 48′; so that to reduce the situations of the westerly and easterly points to their distances from what ought to be considered as their meridian, 20′ must be subtracted from each of the azimuths of the westerly point, and added to each of those of the easterly, similarly to what was done with the observations made in doors. The mean of the observations gives the position of the south point at the same hour 0′.4 W., or so nearly in the meridian, that the observations of this point require no reduction. The observed

azimuths, so reduced to their mean meridian, are to be corrected for the difference between the standard temperature and that of the magnets. By means of tables III. and IV, repeating the processes described for the reduction of the observations made in doors to the standard temperature 60°, I reduce these observed positions of the points of equilibrium to what would have been their positions had the temperature of the magnets been 60° at each of the observations. These reductions are successively effected in the two following tables.

Table of the preceding Observations reduced to their Mean Magnetic Meridian.

	June 19				20				21.				22.				23.				
Time of Observation.	Mean Temperature of the Magnets.	Points of Equilibrium.			Mean Temperature of the Magnets.	Points of Equilibrium.			Mean Temperature of the Magnets.	Points of Equilibrium.			Mean temperature of the Magnets.	Points of Equilibrium.			Mean Temperature of the Magnets.	Points of Equilibrium.			Mean Positions of the South Point.
		West.	East.	South.		West.	East.	South.		West.	East.	South.		West.	East.	South.		West.	East.	South.	
h. m.	°	° ′	° ′	° ′	°	° ′	° ′	° ′	°	° ′	° ′	° ′	°	° ′	° ′	° ′	°	° ′	° ′	° ′	° ′
6 00	54.50	85 30	85 22	0 20 E	55.50	82 30	82 24	0 12 E	55.80	81 26	81 48	0 26 E		No observation.			54.08	82 32	83 06	0 10 E	0 19.0 E
7 30	55.40	84 58	84 44	0 20 E	55.15	83 52	83 22	0 18 E	55.95	81 26	81 40	0 22 E	54.75	83 24	83 22	0 14 E	54.80	83 22	83 18	0 20 E	0 18.0 E
9 00	57.10	85 12	83 58	0 06 E	65.13	77 32	78 28	0 18 E	55.10	82 28	83 14	0 08 E	64.70	78 16	78 24	0 08 E	55.83	82 32	83 06	0 02 W	0 11.3 E
10 30		No observation.			67.00	76 58	77 00	0 20 W	56.30	82 28	82 56	0 06 W	59.15	82 14	81 38	0 06 W	55.63	82 50	83 10	0 14 W	0 10.7 W
Noon.	60.90	81 46	80 38	0 34 W	69.90	76 44	75 02	0 26 W	58.35	81 30	81 00	0 24 W	56.50	83 32	82 44	0 26 W	57.05	83 08	81 20	0 40 W	0 25.3 W
1 30	61.75	80 42	79 06	0 44 W	69.85	75 04	74 40	0 38 W	59.40	79 48	79 12	0 26 W	55.60	82 58	82 14	0 48 W	57.25	81 14	80 14	0 40 W	0 37.3 W
3 00	62.90	78 54	78 18	0 28 W	69.14	75 00	74 22	0 32 W	59.60	79 34	79 00	0 24 W	56.40	81 12	80 54	0 40 W	57.10	80 32	79 40	0 28 W	0 32.0 W
4 30	61.95	79 40	79 18	0 20 W	68.25	74 56	74 48	0 16 W	58.45	78 50	78 52	0 04 W	56.50	81 32	81 04	0 18 W		No observation.			0 12.7 W
6 00	58.40	81 16	80 40	0 00	66.95	75 22	75 14	0 02 W	56.70	79 18	79 24	0 06 E	54.50	82 18	82 08	0 00		No observation.			0 01.3 W
7 30	55.45	82 48	82 26	0 06 E	65.00	75 58	75 58	0 02 W	55.00	80 40	80 52	0 04 E	52.90	83 24	83 28	0 06 W	51.90	82 48	82 54	0 04 W	0 01.3 W
9 00	55.80	82 14	81 50	0 12 W	60.75	78 54	77 58	0 10 W	53.65	81 58	81 58	0 00	51.50	84 34	84 12	0 00	50.65	84 02	84 04	0 00	0 03.3 W

C. *Table of the positions of the Points of Equilibrium at which a Magnetic Needle was retained at different hours during the day, by the joint action of two bar Magnets and of Terrestrial Magnetism, reduced to their true positions at the Standard Temperature* (60°) *of the Magnets.* Note. The observations were made in the open air.

	June 19.			20.			21.			22.			23.			Mean true Positions of the Points of Equilibrium.		
Time of Observation.	Difference of Temperature corrected for	Points of Equilibrium.		Difference of Temperature corrected for	Points of Equilibrium.		Difference of Temperature corrected for	Points of Equilibrium.		Difference of Temperature corrected for	Points of Equilibrinm.		Difference of Temperature corrected for	Points of Equilibrium.				
		West.	East.		West.	East.		West.	East.		West.	East.		West.	East.	Westerly.	Easterly.	South as before.
h. m.	°	° ′	° ′	°	° ′	° ′	°	° ′	° ′	°	° ′	° ′	°	° ′	° ′	° ′	° ′	° ′
6 00	+5.50	81 06	81 02	+4.50	79 48	79 44	+4.20	79 05	79 23	No observation.			+5.92	79 03	79 20	79 26.5	79 33.5	0 19.0 E
7 30	+4.60	81 22	81 13	+4.85	80 31	80 11	+4.05	79 10	79 21	+5.25	79 59	79 58	+5.20	80 06	79 56	79 53.3	79 50.0	0 18.0 E
9 00	+2.90	82 39	81 47	−5.13	80 03	81 14	+4.90	79 31	80 04	−4.70	80 43	80 53	+4.17	79 57	80 22	80 05.7	80 43.7	0 11.3 E
10 30	No observation.			−7.00	80 22	80 24	+3.70	80 10	80 31	+0.85	81 40	81 06	+4.37	80 04	80 19	80 44.0	80 40.3	0 10.7 W
Noon.	−0.90	82 23	81 10	−9.90	81 48	79 20	+1.65	80 31	80 03	+3.50	81 05	80 29	+2.95	81 07	79 38	81 08.0	79 57.3	0 25.3 W
1 30	−1.75	81 47	80 01	−9.85	79 21	78 49	+0.60	79 29	78 54	+4.40	80 09	79 36	+2.75	79 40	78 40	79 39.7	79 06.3	0 37.3 W
3 00	−2.90	80 26	79 45	−9.14	78 55	78 05	+0.40	79 22	78 48	+3.60	79 12	78 57	+2.80	79 02	78 16	79 09.7	78 36.7	0 32.0 W
4 30	−1.95	80 45	80 21	−8.25	78 23	78 13	+1.55	78 06	78 08	+3.50	79 31	79 08	No observation.			78 40.0	78 29.7	0 12.7 W
6 00	+1.60	80 20	79 47	−6.95	78 19	78 09	+3.30	77 43	77 48	+5.50	79 05	78 58	No observation.			78 22.3	78 18.3	0 01.3 W
7 30	+4.55	79 57	79 41	−5.00	78 07	78 07	+5.00	78 05	78 15	+7.10	79 01	79 04	+8.10	78 10	78 14	78 24.3	78 28.7	0 01.3 W
9 00	+4.20	79 43	79 24	−0.75	79 17	78 19	+6.35	78 26	78 26	+8.50	78 59	78 47	+9.35	78 18	78 19	78 54.0	78 30.7	0 03.3 W

The character of the diurnal changes in the positions of the points of equilibrium is very nearly the same for each day, but, in taking the mean, I can only make use of the observations of the 20th, 21st, 22d, since on the 19th no observation could be made at $10^h\ 30^m$, and the azimuths are all greater on this day than on any of the subsequent, and two observations were unavoidably omitted on the 23d.

Comparing the results with those obtained from the observations made in doors, we find them agree as nearly as could possibly be expected. From table A it appears, that when the observations were made in doors, the westerly point receded from the north until half past 10 o'clock in the morning, and approached the north during the remainder of the day until about 9 in the evening; and from table C, that when they were made in the open air, the westerly point receded from the north until about half past eleven in the morning, and approached it until six or seven in the evening, after which it again gradually receded. This is not a greater variation in the times of the maxima than we find on different days, either in the in-door observations, or in those in the open air. The easterly point appears to have receded from the north until about 10 o'clock in the morning, when the observations were made in doors and likewise when they were made in the open air; and to have approached it until between nine and ten in the evening in the former case, and until six in the latter.

Taking, as before, half the sum of the mean easterly and westerly arcs at different hours during the day as the mean azimuths of the points of equilibrium at those hours, and substituting these for φ in the equation (α_4),

$$M - F\,(.00448032 + .0007664093\ \cos.^2\varphi) = o,$$

I obtain the values of M in terms of F, at those hours; and dividing each of these values by the minimum value of M, I find, as before, the relative terrestrial magnetic intensities at the times of observation.

D. *Table of the mean Terrestrial Magnetic Intensities at different hours during the day, deduced from the preceding observations.* Note. The observations were made in the open air.

Time of Observation.	Mean of the Observations of June 20, 21, 22.	
	Azimuth of the Point of Equilibrium.	Terrestrial Magnetic Intensity.
h. m.		
6 00	79 30.0	1.00112
7 30	79 51.7	1.00061
9 00	80 24.7	1.00028
10 30	80 42.2	1.00000
Noon.	80 32.7	1.00015
1 30	79 23.0	1.00134
3 00	78 53.2	1.00188
4 30	78 34.8	1.00223
6 00	78 20.3	1.00251
7 30	78 26.5	1.00239
9 00	78 42.3	1.00209

From these it appears, that the minimum intensity happened nearly at the time the sun passed the magnetic meridian, and rather later than in May, which was also the case with the time of the sun's passage over the meridian:* the

* The diurnal variation, both in the direction of the needle and in the magnetic intensity, appears to have a reference to the position of the sun with regard to the magnetic meridian; it is therefore probable, that the sun is the principal cause of both

intensity increased until about six o'clock in the afternoon, after which time it appears to have decreased during the

these phœnomena. The circumstance of the situation of the magnetic pole in what appears to be, independent of elevation, the coldest region of the globe, supported as it is by the fact of a diminution of temperature causing an increase of magnetic intensity, would lead us to infer, that the effect produced by the sun is principally to be attributed to the heat developed by it; but should any periodical effects, corresponding to the time of the sun's rotation about its axis, be observable in the diurnal variation, we must suppose that the sun, like the earth, is endued with magnetism, and look for a cause of this magnetism, common to all the planets. Being engaged more than two years ago in making some experiments on the effects produced on the needle by unpolarized iron, I discovered that a peculiar polarity was imparted to the iron by simply making it revolve about an axis; and this naturally suggested the question to me, whether the magnetism of the earth, and consequently, that of the other planets and the sun, might not be owing to their rotation? From the effects which I have observed to be produced on iron by its rotation, it appears probable, if the magnetism of these bodies be not caused by their rotation, that at least the effects will be modified by, and, to a certain extent, dependent on such rotation. Since first observing the fact, that simple rotation will cause a peculiar polarity, if I may be allowed the expression, in iron, I have made a great variety of experiments on the subject, which have enabled me to trace the laws according to which this polarity in the iron affects a magnetic needle, independently of the effect produced by the mass. It would lead me to too great a length here to state the several effects that are produced by the rotation of iron, or the laws which govern them; but I will briefly mention one. Let us imagine a plane to pass through the centre of an horizontal needle, at right angles to the meridian, and making an angle with the horizon equal to the dip; then, if the plane of a circular plate of iron coincide with this plane, and the plate be fixed on an axis passing through its centre at right angles to its plane, so that it can be made to revolve in its own plane, the direction of the needle will be different, according as the several points of the plate are brought into any particular position by making it revolve in one direction or the opposite, excepting in four positions of the centre of the plate. If the centre of the plate be successively placed to the east or west of the centre of the needle in the same horizontal line, and over the needle in the plane of its meridian, then the deviation of the needle due to the rotation of the plate will be in contrary directions in the two cases, the plate revolving in the same direction in both. These and other peculiar effects arise

evening, and to have been decreasing from an early hour in the morning.

The general agreement of these intensities with those deduced from the observations made in doors, is as near as could be expected, considering that an interval of twenty days had elapsed between the two sets of observations. From this, and the agreement in the manner in which the westerly and easterly points of equilibrium approach and recede from the north in the two cases, which I have before pointed out, we may conclude, that there is nothing anomalous in the action which takes place on the needle under the different circumstances of its being placed in doors or in the open air; and that the apparent anomaly in the directions of the needle in the two cases, which was observed by Mr. BARLOW and myself, arose from the cause which I have assigned for it in my former paper; namely, the difference in the changes of temperature in the magnets when in doors and when in the open air.

The diurnal changes in the terrestrial magnetic intensity have been determined by Professor HANSTEEN, by means of the vibrations of a needle delicately suspended. From these observations it appears, that in general the time of minimum intensity was between ten and eleven o'clock in the morning; that the maximum happened between four and seven

entirely from the rotation of the iron, and are not produced by any friction on the axis. As the effects are not very considerable, to render them conspicuous it is necessary to make use of a plate eighteen inches in diameter, and to have its centre within sixteen inches of that of the needle. If the needle is under the influence of magnets, as in the foregoing observations, the effects produced by the rotation of the plate are considerable.

for the month of May 1820, and about seven o'clock in the evening for the month of June. The intensity which, in these observations, is taken as unity, is that deduced from an observation made during an aurora borealis; but for the purpose of comparison, I have, for the months of May and June, taken the intensity deduced from his observations at $10^h\ 30^m$ in the morning as unity, reduced the intensities, which he gives for other times in the day, to this standard, and placed them in the following table, with the corresponding intensities deduced from my own observations.

Intensity deduced from HANSTEEN'S Observations in 1820.			Intensity deduced from the preceding Observations in 1823.		
Time.	May.	June.	Time.	May.	June.
h. m.			h. m.		
8 00 A. M.	1.00034	1.00010	7 30 A. M.	1.00114	1.00061
10 30	1.00000	1.00000	10 30	1.00000	1.00000
4 00 P. M.	1.00299	1.00251	4 30 P. M.	1.00175	1.00223
7 00	1.00294	1.00302	7 30	1.00220	1.00239
10 30	1.00191	1.00267	9 30	1.00231	1.00209

The principal difference to be observed in the nature of the changes of intensity during the day, in the two cases, is, that from my observations, the intensity appears to decrease more rapidly in the morning, and increase more slowly in the afternoon, than it does from those of Professor HANSTEEN; but the general character of these changes is as nearly the same as we can expect from methods so different, at different times, and at places where both the variation and dip of the needle are different. My object however was, to point out

what might be deduced from a series of such observations as I have detailed, rather than to compare the results deduced from them with those obtained by others, for which purpose it would have been necessary to have continued them for a greater length of time.

We have seen that with the magnets I made use of, their intensity being nearly 218 M, at the temperature 60°, a change in their temperature of 1° would cause a change of intensity of 0.123 M; or taking the intensity of the magnets 1, for each degree of increase in temperature we should have a decrease of intensity of 0.000564. Now if the same, or nearly the same, take place with all magnets, it is evidently necessary, in all cases where the terrestrial magnetic intensity is to be deduced from the vibrations of a needle, that great care should be taken to make the observations at the same temperature; or, the precise effect of change of temperature having been previously ascertained, to correct the observations according to the difference of the temperatures at which they were made. I am not aware that any one has yet attempted to make such a correction; but it is manifest from the experiments I have described, that it is indispensible, in order to deduce correct results from the times of vibration of a needle in different parts of the earth, where the temperatures at which the observations are made are almost necessarily different, that these temperatures should be registered, and the times of vibration reduced to a standard of temperature. It appears to me, that the effects will be the most sensible in large and powerful needles; and consequently, in making use of such, the reduction for a variation of temperature will

be most necessary. There would be no difficulty in this reduction, if we could give in terms of the intensity of any magnet the increment or decrement of intensity corresponding to a certain decrement or increment of temperature at all temperatures. To determine this accurately, would however require a great variety of experiments to be made with magnets of very different intensities; but as I have not made these, I must content myself for the present with pointing out some of the facts which I have ascertained from more extended experiments than those I have already given, reserving the detail of these experiments for another opportunity, should they be deemed of sufficient interest.

These experiments were made with a balance of torsion, the needle being suspended by a brass wire $\frac{1}{450}$ inch in diameter: by them I ascertained the following facts:

1. Commencing with a temperature — 3° FAHRENHEIT, up to a temperature 127°, as the temperature of the magnets increased, their intensity decreased. Owing to the almost total absence of snow during the winter, I was unable to reduce lower the temperature of the large magnets which I made use of; but from an experiment I made at the Royal Institution, in conjunction with Mr. FARADAY, in which a small magnet, enveloped in lint well moistened with sulphuret of carbon, was placed on the edges of a basin containing sulphuric acid, under the receiver of an air pump, I found that the intensity of the magnet increased to the lowest point to which the temperature was reduced, and that the intensity decreased on the admission of air into the receiver, and consequent increase of temperature in the magnet. This

is in direct contradiction to the notion which has been entertained of destroying the magnetism of the needle by the application of intense cold.

2. With a certain increment of temperature, the decrement of intensity is not constant at all temperatures, but increases as the temperature increases.

3. From a temperature of about 80° the intensity decreases very rapidly as the temperature increases: so that, if up to this temperature, the differences of the decrements are nearly constant, to ascertain which requires a precision in the experiments that perhaps their nature does not admit of, beyond this temperature, the differences of the decrements also increase.

4. Beyond the temperature of 100°, a portion of the power of the magnet is permanently destroyed.

5. On a change of temperature, the most considerable portion of the effect, on the intensity of the magnet, is produced instantaneously; showing that the magnetic power resides on or very near the surface. This is more particularly observable when the temperature of the magnet is increased, little change of intensity taking place after the first effect is produced; on the contrary, when the temperature of the magnet is diminished, although nearly the whole effect is produced instantly, yet the magnet appears to continue to gain a small power for some time.

6. The effects produced on unpolarized iron by changes of temperature are directly the reverse of those produced on a magnet; an increase of temperature causing an increase in the magnetic power of the iron, the limits between which I observed being 50° and 100°. That the effect on iron of an

increase of temperature should be the reverse of that produced on a magnet, is, I think, a strong argument against the hypothesis, that the action of iron upon the needle arises from the *polarity* which is communicated to it from the earth.

It may be objected to the method which I have adopted for determining the diurnal changes in the terrestrial magnetic intensity, that, after the observations have been made, they require a correction for temperature, which can only be determined by experiments previously made on the magnets and needle employed. The same objection may, however, be made against the method of determining the intensity by the vibrations of a needle. As such a correction has not in the latter case been hitherto applied, the results which have been obtained relative either to the diurnal changes of intensity, or the intensities in different parts of the earth, by means of observations on the vibrations of a needle, will be so far incorrect as the needle may happen to have been affected by differences in the temperature. The method I have described, however, possesses advantages over the other: a very considerable one is, that whatever effects are produced may easily be observed with considerable precision, the time required for each observation being not more than five minutes; another is, that, the magnets being immersed in water, as far as regards them, we may command the temperature at which the observations are to be made, and thus limit the correction for temperature to a very small quantity; and it possesses another decided advantage, that whatever are the effects produced on the needle by atmospheric changes, they are, by means of it, rendered immediately visible, and can be observed as they occur.

It was my intention to commence a series of such observations at the beginning of the present year, and to continue them for as long a period as I was able; but circumstances prevented my commencing at the time I proposed, and ill health has since put it out of my power to engage in such continued observations as would be required: but I trust the task will be undertaken by others who feel interested in investigating the phœnomena connected with terrestrial magnetism.